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A 350-FT. BRICK CHIMNEY FOR ACID CHEMICAL GASES.

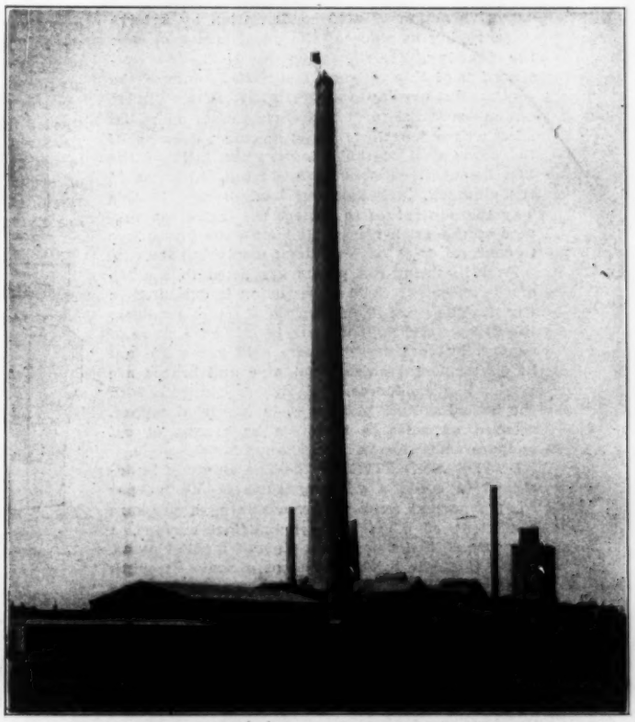
By Theodore Lindeman.*

A brick chimney of unusual height has been completed within the past few months at the chemical works of The Heller & Merz Co., at Newark, N. J. The chimney stands 350 ft. high above the ground, and thus takes a prominent place among tall chimneys in America. The chimney will handle acid gases at a maximum temperature of 1,000 to 1,500° F. It is fully lined from ground to top with a lining of fire-and-acid-proof brick.

The conditions which led to the construction of this stack were as follows: The chemical works, which have been at their present location for many years, have long used small chimneys, 125 ft. high or less, to carry off the acid fumes of the smelting furnaces. Originally the works were outside of the city of Newark and the fumes were unobjectionable. In the course of time, however, as Newark expanded in every direction, the built-up portion of the city extended close to the plant, and the sulphuric and nitric acid fumes then became a serious nuisance in the neighborhood. A study of the situation, with the advice of numerous consulting experts, finally led the owners to decide upon a tall chimney which would discharge the gases at such a height that they would no longer do injury in the neighborhood. Subsequently bids were received on various designs of chimneys, and a contract was made with the Alphons Custodis Chimney Construction Co., New York City, for the construction of a 350-ft. chimney of radial brick, to carry acid fumes at a maximum temperature of 1,500° F. The chimney was completed under this contract in the month of November, 1905.

A general elevation, section and plan of the Heller & Merz chimney are shown in Fig. 1 of this article. As there indicated, the structure rests on a pile foundation. The soil at the site is soft, marshy ground and the foundation was designed only after thorough study of the local conditions. Borings made at several different places showed that rock would be found at a depth of 60 ft. below ground, and the test piles demonstrated that it would be practicable to drive piles down to rock. It was considered safe to load piles up to 15 to 20 tons. As designed and built, the foundation contains 324 piles in staggered spacing, about 2½ ft. apart, forming a square 45 ft. on a side. Yellow pine piles were used, 14 ins. at the butt and 6 ins. at the point, of 60 ft. minimum length; they were driven with a 3,000-lb. drop hammer and were cut off 3 ft. below the surface of the ground to receive the concrete base block. The pressure on the foundation piles under the maximum wind pressure (50 lbs. per sq. ft. on a plane surface, equivalent to 25 lbs. per sq. ft. on projected cylinder surface) is 19 tons per pile at the leeward edge.

A few feet below the surface of the ground at the site quicksand was encountered. It was necessary, to avoid very difficult working, to keep the excavation for concrete well above the top of the quicksand. For this reason the concrete, as shown in Fig. 1, extends only 4 ft. below the original ground surface, having a 1-ft. grip on the pile heads. The total depth of concrete foundation block is 14 ft. At the base this block is square, at the top it is octagonal, and the general form is pyramidal. The base was made of Atlas Portland cement, sand and crushed stone in a 1:3:5 mixture, machine mixed and tamped in 12-in. layers. Its total volume is 766 cu. yds. The stack itself is a brick cone of uniform taper, whose inside top diameter is 8 ft. in the clear. The outside diameter at top (fixed by the minimum desirable thickness of structural brick work 7⅛ ins., plus the thickness of the lining, 4 ins.) is 9 ft. 10¼ ins.; the outside diameter at the bottom is 27 ft. 6½ ins., and the taper of the stack is 5.2 in 100. The bottom diameter is fixed principally by the requirement that there shall be no tension in the brickwork on the windward side under maximum wind-pressure.



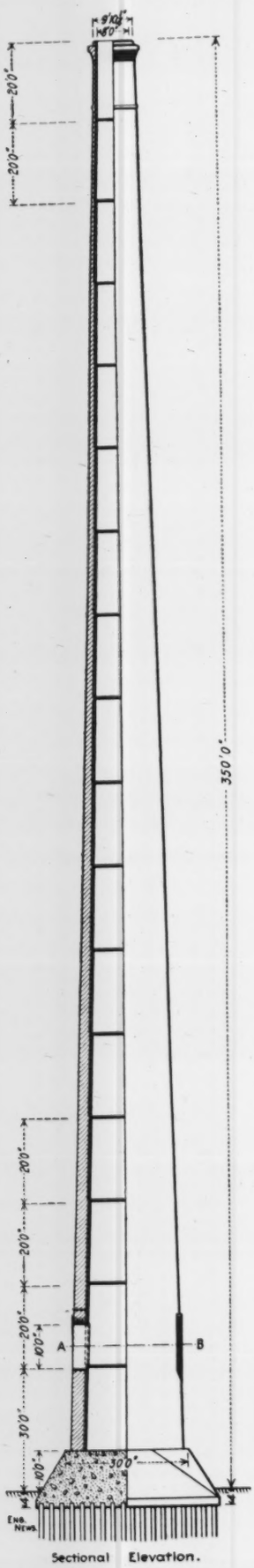
VIEW OF COMPLETED 350-FT. CHIMNEY FOR ACID GASES AT WORKS OF THE HELLER & MERZ CO., NEWARK, N. J.
Height, 350 ft.; Clear Opening at Top, 8 ft.
Alphons Custodis Chimney Construction Co., Contractor.

The outer shell or main portion of the stack is constructed of perforated radial brick of the usual Custodis pattern, laid in lime-cement mortar of 1 part cement, 2 parts lime, 5 parts sand. It is 38 ins. thick at the bottom and 7⅛ ins. at the top; the changes in thickness are made by 2-in. offsets on the inside, every 20 ft. in height. The shell is banded at the top by a 3½ × 5/16-in. wrought-iron band around the brickwork three courses below the top of the stack; this band is bedded in mortar consisting of 1 part cement and 1 part sand. Banding the main body of the stack, which is resorted to wherever explosions of gases in the stack are to be apprehended, was not required.

The Custodis chimney brick is distinguished by its "radial" or segmental form, its large size and its vertical perforations. It is made segmental to lay up easily in circular work, and for this purpose is made to different radii to suit the varying diameters in a single chimney and in different chimneys. About twenty different radii are carried in stock, the smallest giving an inside diameter of 2 ft. 6 ins. Vertical perforations, 1 in. square, are formed in the brick, in such number as to leave about ¾-in. to 1 in. material between them. These holes have a double purpose—first, they allow the flame of the kiln to pass through them, so that the brick is more thoroughly burned and a much larger brick can be made than ordinary solid brick; and, second, the mortar in which the brick is laid enters partly into these holes and forms a much stronger bond than that of ordinary brickwork. These effects are shown by the high strength of these bricks, the tensile strength of the brickwork and the large size of the blocks which is successfully employed. The standard sizes of Custodis bricks are made of uniform thickness (4 ins.) and circumferential width (6½ ins.), but of different radial lengths (4, 5½, 7⅛, 8⅝, 10⅝ ins.) to make thorough bonding of the brickwork possible. The smallest size has six perforations, while the largest size has fifteen. The fact that these bricks are much larger than ordinary building brick makes the work of laying them up materially cheaper and quicker.

The stack is lined for its full height with a 4-in. thickness of special brick having high resistance to heat and acids. The lining is sec-

*Engineer, Alphons Custodis Chimney Construction Co., Bennett Building, New York, N. Y.



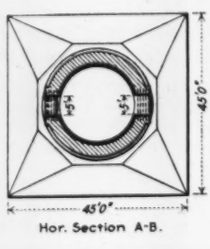


Fig. 1. Elevation, Plan and Sections of 350-Ft. Chimney with Acid-Proof Lining.

The Heller & Merz Co., Newark, N. J.

tional, being carried on corbels projecting from the main shell every 20 ft., at the points where the changes in the shell thickness are made. A clear space of 2 ins. is left between lining and wall as insulating air-space. The detail sketch Fig. 2 shows the corbel support. The lining bricks are also of the radial perforated type, and correspond in size to the smallest shell brick, 4 × 6½ × 4 ins. They are laid in a mortar made of silicate of soda and white asbestos wool, tempered to the consistency of fire-clay mortar. This mortar is acid-proof, and its binding power, which is considerable in comparison to that of fire-clay mortar, is unaffected by temperatures up to 2,000° F.

The sectional construction of the lining (which is covered by patent) gives the important advantages of cheapness and ease of repair. A self-supporting lining requires to be much thicker at the bottom, while the sectional lining is of uniform minimum thickness from top to bottom. If any part of the lining should become damaged or wear out sooner than other parts, one or more sections may be taken out and replaced without disturbing the others, while a self-supporting lining would require complete renewal or else would make a difficult and delicate piece of repair work. The sectional lining has been a complete success in all the chimneys to which it has been applied; the 365-ft. chimney of the Orford Copper Co., Constable Hook, N. J., which is the tallest chimney in America, has this form of lining and has been in operation for nearly five years, carrying gases at temperatures from 1,200° to 1,500° F., without interruption or damage.

The top of the chimney is protected from the corrosive action of acid condensation by a terra cotta coping in place of the usual cast-iron cap; the drawing, Fig. 3, shows in detail the construction of this coping. The radial joints of the coping tiles overlap and are made tight with 1:1 cement-sand mortar. The coping rests on radial ribs, whose length is equal to the thickness of the outer wall of the chimney; the body of the tile, however, extends over the full thickness of the chimney, including the 4-in. lining. In this way the cap serves to protect the entire top surface of the brick-work, but leaves the lining free to contract or expande without displacing the cap.

Four lightning-rod points are fitted to the top of the chimney; their construction is exhibited in Fig. 4. The point itself is made of retort graphite; the fittings and supports are in this case made of copper, but ordinarily, where acid gases are not in question, galvanized-iron pipe and braces are used. The conductor cable which connects with the buried ground plate is ½-in. stranded copper, secured at suitable intervals by means of set anchors whose heads form clamps for the cable.

LOADS AND STRESSES.—The chimney is designed to resist a wind pressure of 50 lbs. per sq. ft., normal surface; or, assuming a pressure coefficient of 0.5 for the cylindrical surface, a pressure of 25 lbs. per square foot of median plane.

The Custodis brick has a compressive strength of about 5,000 lbs. per sq. in., gross section. When laid up in brickwork it has a tensile strength of about 60 to 65 lbs. per sq. in. Ordinarily, in designing chimneys of this kind, a tension of 20 to 25 lbs. per sq. in. is allowed, but in the present case it was desired to avoid all tension. The maximum stresses in the brickwork just above the base, under maximum wind pressure, are: Compression on leeward side, 256 lbs. per sq. in.; compression on windward side, 17 lbs. per sq. in.

The following amounts of material were employed in the construction of this chimney: Foundation—1,000 bbls. cement, 400 cu. yds. sand, 800 cu. yds. crushed stone. Stack—2,000 tons brick, 500 bbls. cement, 800 bbls. lime, 600 cu. yds. sand. The contract price for the stack, including the concrete foundation and the piling, was $32,000. The time required for the work was seven months. Figs. 5 and 6 show the chimney in different stages of its erection. The completed structure is shown in the photograph reproduced on the first page of this issue.

Another large chimney of this type has recently been completed at Garfield, near Salt Lake City, Utah, for the American Smelting & Refining Co. This stack is 300 ft. high and 30 ft. inside diameter at the top; it is lined for a height of 100 ft., and is to carry smelter gases of relatively low temperature due to traveling through a very long flue. In point of capacity this is the largest chimney in the world.

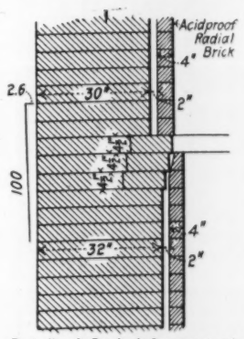
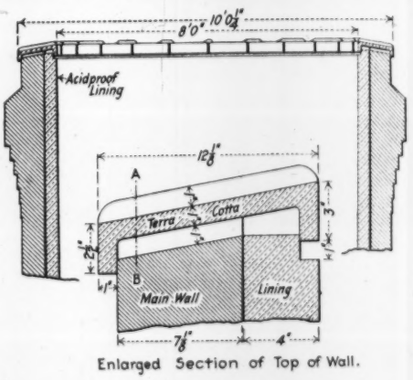


Fig. 2. Detail of Corbel Support of Lining.

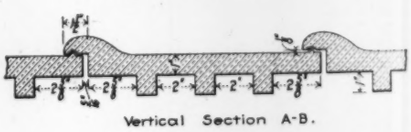
THE CONSULTING ENGINEER AND THE ARCHITECT

By H. S. K.

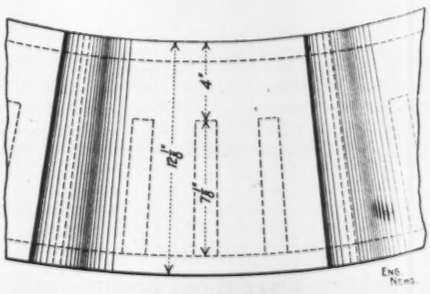
One of the most interesting features of modern industrial development is found in the highly specialized organization of labor necessary to carry great undertakings to a successful completion. The "all around" or general utility man has practically disappeared, for the requirements of present-day business have little opportunity for the rather indefinite usefulness and capabilities of the worker who is untrained in some particular branch and whose industrial value lies in his general knowledge alone. From the ranks of organized labor to the highest circles of professional activity the specialist prevails. We are living in a day which appreciates the worth



Enlarged Section of Top of Wall.



Vertical Section A-B.



Part Top Plan.

Fig. 3. Detail of Terra-Cotta Coping of Chimney.

of expert knowledge as perhaps it has never been appreciated before, and, although extreme specialization sometimes leads to narrowness, there is no doubt that the tendency to exalt the value of accurate detailed knowledge and deep-cut experience in definite lines is sound.

Industrial progress has been so rapid within the last half century that no one man can keep in accurate touch with all the epoch-making work in more than one profession, let alone the difficulty of being constantly informed in the advances of his own chosen field. Few electrical engineers in street railway practice, for example, find it possible to keep informed as to the detailed advances in the central station field, and certainly the electrical engineer whose mental horizon includes, besides his own daily practice, a thorough and reliable knowledge of civil engineering design is a rara avis. In exceptional cases these specialties may overlap, but in general the professional expert in any single line or in any two or three specialties has his hands too full to devote any time to the mastery of industrial branches outside his regular field. Although the relations between different branches of professional work are more or less intimate in many undertakings, notably in building construction, it seldom is desirable that all the consultation work shall be done by any single advisory expert.

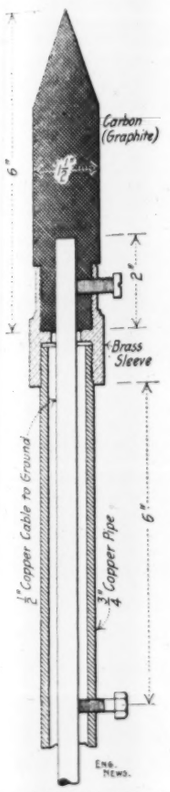


Fig. 4. Detail of Lightning Rod Point.

In this connection some interesting matter has lately been printed in the technical press in regard to the relations between architects and engineers. The exact sphere of each one of these specialists in building construction is not always sufficiently defined to produce the most satisfactory results, particularly as the client frequently trusts rather too implicitly to his architect in matters outside the latter's proper jurisdiction, often, in fact, dispensing entirely with the services of the engineer.

The very frequent method of allowing contractors to submit "gratis" plans for that portion of the equipment of a building of which the architect has no real expert knowledge is of very questionable value. That it solves the architect's problem of securing certain plans without expense to himself does not always mean that the client really gets something for nothing. In architectural circles where a high standard of professional ethics prevails the client is properly advised to secure a consulting engineer's services in technical matters outside the architect's regular practice, but in other instances the client's interests are frequently overlooked in the matter of expert advice.

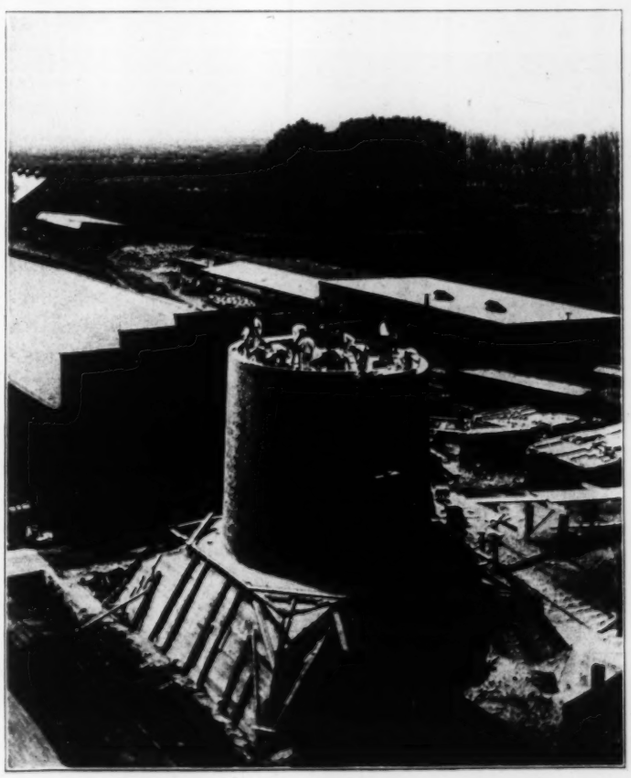
Not long ago a certain firm of architects invited a very limited number of contractors to submit plans and proposals for the heating of a large country residence and its outbuildings, calling for alternative layouts for steam and hot water. As complete working drawings were required, this meant considerable expense to the bidders, as it was mutally agreed to add 10% to each of the individual bids—the successful bidder to divide this amount among his less fortunate competitors.

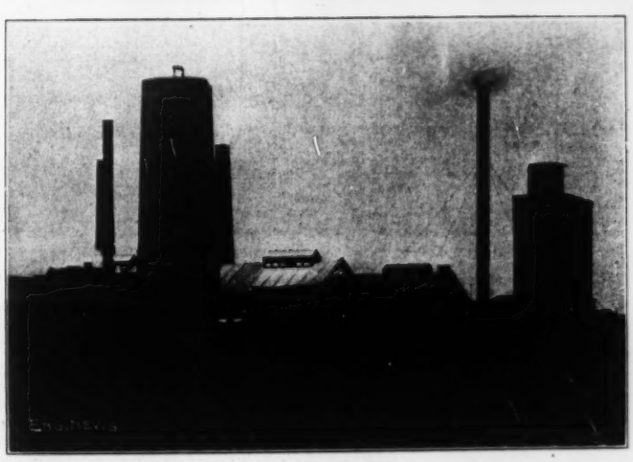
Practices of this kind are by no means uncommon, and it is easy to sympathize to a certain extent with the contractor who really does expert work for the architect's client in the engineering line and who feels that he is justly entitled to some compensation for it. The architect or engineer who shifts the responsibility, labor, and expense of drawing plans and specifications upon the contractor, without the knowledge of his client, is the real cause of the above conditions, and it is not going too far to call such practices gross violations of professional ethics.

The practice of accepting bids from only a very limited number of contractors is fraught with equally irregular possibilities, and the processes of "loading" and "getting protected," as the trade designations run, deserve the severest criticism. Any plan for making a client pay for engineering service without knowing that he is doing so injures legitimate engineering practice no less than it violates the traditions of common honesty.

"Loading" is a system whereby the contractor who is making the plans "for nothing" specifies either a larger quantity of material or greater heating surface, for example, with heavier pipes, more expensive valves and specialties, etc., than he has any intention of providing, should he—as is highly probable—be awarded the contract. The other contractor who is asked to bid on these plans must follow them to the letter or pay the penalty, for the maker of the plans is also in effect—though possibly not in name—the superintendent of the job.

"Getting protected" means specifying some patented system or specialty, and in return getting the manufacturer to quote a higher price for it to all other bidders. The client pays the difference, and the consulting engineer is passed by as unnecessary. In heating and other engineering propositions in connection with buildings the architect has an important part to play in harmonizing the equipment and in suiting his plans to the requirements of the mechanical and structural parts of the work, and for this he is justly entitled to some remuneration, but probably not the full commission. The same reasoning applies to the engineer in reference to architectural problems. In some quarters, for example, a commission of 5% to the engineer and 1.5% to the architect on the mechanical equipment of a building is considered satisfactory. The client is not likely to object to such an arrangement if it is properly presented to him, for no sensible business man expects in these days to get "something for nothing."





FIGS. 5 AND 6. TWO VIEWS OF 350-FT. CHIMNEY DURING CONSTRUCTION.

GASOLINE AND OIL TRACTION ENGINES have been built to the order of the British War Office by John I. Thornycroft & Co., of London, England. The larger machines have four-cylinder engines, developing 40 HP. on the brake at 600 revolutions per minute. The cylinders are 6 × 8 ins. Power is transmitted to the rear axle through a friction disk clutch running in oil and a four-speed gear box. The gears are all enclosed in oil retaining dust-proof casings, and are 18 ins. clear from the ground. The machine can carry fuel and water for a run of 100 miles. It was guaranteed to have a load of 5 tons, but in an official test it hauled 14 tons up a grade of 8½% and 7 tons over soft ground. It also hauled its load out of the soft ground by the cable and drum attachment. The smaller machine has two cylinders, 6 × 8 ins., and has made a road trial trip of 200 miles; it hauls a searchlight plant and drives the generator for that plant. The power transmission is by bevel gears to a countershaft, and then by a Renold silent chain to the differential gear on the rear axle.

A "GOOD ROADS" TRAIN is to be sent out by the Chicago & Alton Ry. in February, stopping at numerous points for lectures and the demonstration of the machinery carried by the train. The technical party with the train will include, as representatives of the University of Illinois, Prof. I. O. Baker, Dean Davenport (College of Agriculture) and Prof. F. R. Crane (Instructor in Farm Mechanics). It will also include Mr. A. N. Johnson, State Highway Engineer. Mr. Joseph R. Falkerson, of the Illinois State Highway Commission, and Mr. D. W. King, of the Missouri Highway Commission, will also accompany the train and deliver addresses.

TESTS OF REINFORCED CONCRETE BEAMS, CHICAGO, MILWAUKEE & ST. PAUL RY.*

By J. J. Harding, M. W. S. E.†

During the past few years, more especially since 1902, a large number of tests have been made by well known investigators to determine the action of reinforced concrete beams under cross bending. In spite of the wide variation in the design of the beams which have been tested from time to time and in the methods used in making these tests, the strength of reinforced concrete beams under flexure has been fairly well established in so far as it refers to a bending moment failure. The liability of a failure due to excessive shearing stresses, however, is something upon which we have very little experimental data, although this liability is quite generally recognized by engineers.

It is true that beams, both with and without diagonal reinforcement, have been tested, but in many cases the design in other respects or the method of loading precluded the possibility of a diagonal failure.

In Volume IV. of the Proceedings of the American Society for Testing Materials is published a number of very interesting papers on "Tests of Reinforced Concrete Beams." The writer wishes to quote from two of these papers. Prof. A. N. Talbot, in his report of some tests made at the University of Illinois, on beams both with and without diagonal reinforcement, states under the head of shear and adhesion that "In no case was there a crack or failure of the kind usually attributed to shear."

Prof. F. E. Turneaure, on the contrary, found, in the tests made at the University of Wisconsin, on beams both with and without diagonal reinforcement, that "In but few cases was the failure free from the influence of shearing stresses, the rupture usually occurring outside the load and on a diagonal line."

A careful study of the two sets of tests will, of course, bring to light a number of good and sufficient reasons why such diametrically opposite results were obtained, the principal ones being, perhaps, the difference in the manner and percentage of the steel reinforcement, in the richness of the mixtures and in the ratio of the depth of the beams to the length of the spans.

It is not, however, the intention in this paper to enter upon a discussion of the above mentioned tests, the quotations being given here merely to emphasize the desirability of further investigation into the liability of a tension failure in a reinforced concrete beam, caused by excessive shearing stresses.

The Chicago, Milwaukee & St. Paul Railway uses a considerable amount of reinforced concrete in the covers of flat top culverts and is naturally interested, first, in the safety of this class of work, and, second, in its economical design. It was therefore chiefly with the desire of obtaining some additional information upon this phase of the question, which might be of value in designing the covers of flat top culverts, that a number of beams were made and tested by the Bridge and Building Department of that road.

*Reprinted from the Journal of the Western Society of Engineers.

†Engineer of Masonry Construction, C., M. & St. P. Ry., Chicago, Ill.

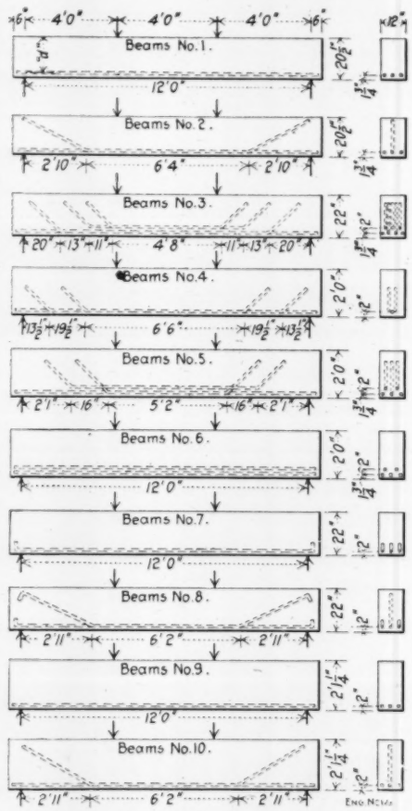


Fig. 1. Diagram Showing Construction of Test Beams.

DESCRIPTION OF BEAMS.—In designing the beams it was decided that but one percentage of reinforcement should be used, since only a limited number of tests could be made, and it was deemed advisable to make them as corroborative as practicable. The amount of reinforcement, about 0.75% of the area of the concrete above the center of the steel, was decided upon for reasons that will be discussed later. "Ransome twisted," "Johnson corrugated," "Kahn trussed" and plain round bars were used.

In order to develop large unit shearing stresses the ratio of distance above the center of steel reinforcement to the length of the span was made as large as circumstances would permit, and still keep the size of the beam within the limits of actual construction.

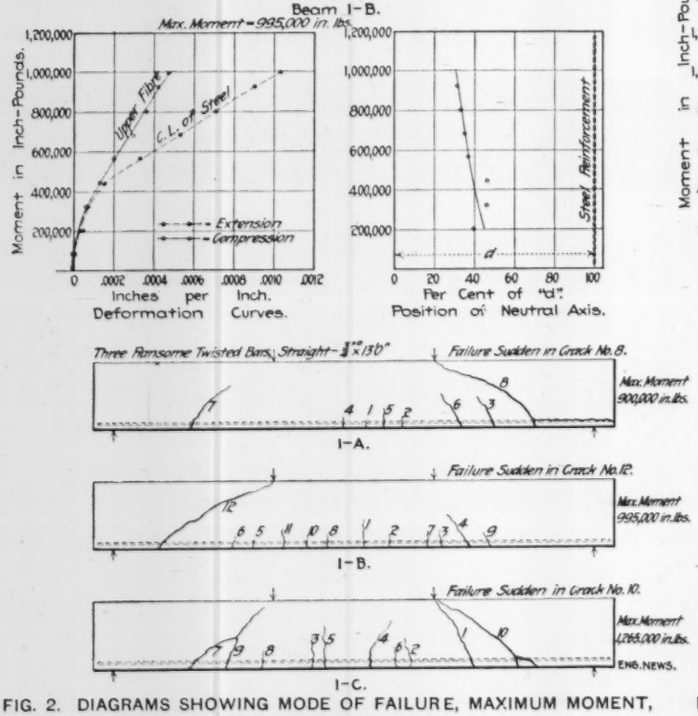
The length of span was fixed at 12 ft., which was about the limit of our testing machine. All of the beams were made 12 ins. wide, and the depth was varied with the number and size of the bars, so as to keep the percentage of steel to concrete constant.

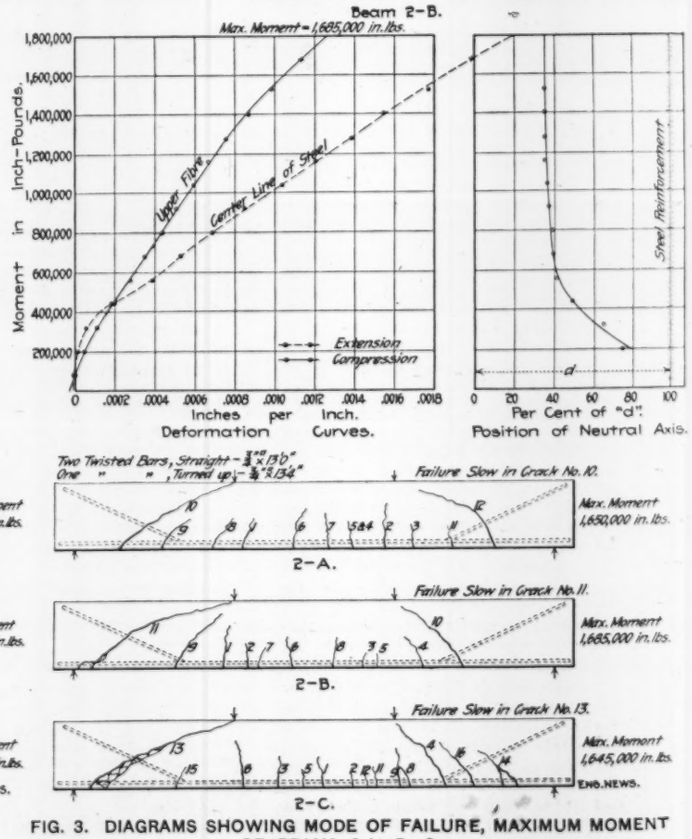
Ten different sets of three beams each were made, as shown in Fig. 1. This small number necessarily limited the range of the tests, but the results obtained are doubtless much more valuable and conclusive, representing in each case an average of three tests, than would a larger number of tests on single beams. Ten forms were made, one for each size beams, and were used at intervals of six days for making the three sets.

CONCRETE.—A moderately wet mixture was used, made up of 1 part Portland cement, Atlas brand, 2 parts of clean sand, from La Crescent, Minn., and 5 parts of crushed limestone "crusher-run," under 2 ins., from the Lannon stone quarries. The bottom surface, up to the top of the bars, was made of 1:2 mortar, as is our practice in actual construction.

On account of the low temperature at the time the beams were constructed, the strength of the concrete was somewhat below the average of that generally used by the railway company. Six-inch cubes made from the same batch of concrete as was used to make beams 10 B and 10 C developed a compressive strength of 1,570 lbs. and 1,480 lbs. per sq. in., respectively, when four months old. Cubes from beams 1 A, 10 B and 8 C, made from the mortar only, developed 2,275 lbs., 1,930 lbs., and 1,720 lbs. per sq. in., respectively, at the same age.

While it is unfortunate for many reasons that the beams could not have been made and kept at a uniform temperature of between 60° and 70° F., until tested, still the extremes of temperature are conditions that have to be met with in actual practice, and it is perhaps better to have the aggregate used for test purposes somewhat below the average, rather than above.





Three Ransome Twisted Bars, Straight - 3/4" x 13'0"
Failure Sudden in Crack No. 8.
Max. Moment 900,000 in. lbs.
1-A.
Failure Sudden in Crack No. 12.
Max. Moment 995,000 in. lbs.
1-B.
Failure Sudden in Crack No. 10.
Max. Moment 1,765,000 in. lbs.
ENG. NEWS.
1-C.

FIG. 2. DIAGRAMS SHOWING MODE OF FAILURE, MAXIMUM MOMENT, ETC., OF BEAMS 1 A, B, C.

Two Twisted Bars, Straight - 3/4" x 13'0"
One " " Turned up - 3/4" x 13'4"
Failure Slow in Crack No. 10.
Max. Moment 1,650,000 in. lbs.
2-A.
Failure Slow in Crack No. 11.
Max. Moment 1,685,000 in. lbs.
2-B.
Failure Slow in Crack No. 13.
Max. Moment 1,645,000 in. lbs.
ENG. NEWS.
2-C.

FIG. 3. DIAGRAMS SHOWING MODE OF FAILURE, MAXIMUM MOMENT OF BEAMS 2 A, B, C.

The general results, however, did not indicate that the concrete in the beams was materially affected by the low temperature.

METHOD OF TESTING.—The beams were broken when about four months old on a 200,000-lb. Olsen testing machine in the railway company's shops at West Milwaukee, Wis. The testing machine was not equipped with an extension table, so that special arrangements were made for supporting the beams and applying the load.

All of the beams were broken on a 12-ft. clear span by loading at the one third points, rollers being used at both the loading points and at the supports, to allow for any longitudinal movement.

Through the kindness of Prof. F. E. Turneaure, of the University of Wisconsin, who loaned the company his extensometer apparatus, we were able to measure the longitudinal deformations of the upper and lower fibers on 10 out of the 30 beams tested. It was originally intended to have these measurements taken on all 30 beams, but unfortunately our tests were delayed somewhat, owing to a press of other important matters, and the apparatus was required at the University of Wisconsin before our work was completed. We were, however, able to obtain the deformations on one of each size of the beams.

DESCRIPTION OF TESTS.—Figs. 2 to 11, inclusive, give in detail the make up of the beams and all the data obtained from the tests, including the deformations of the upper and lower fiber and positions of the neutral axis for beams B, and the development of cracks, method of failure, and the maximum moment in inch pounds developed in each beam.

In Figs. 2 and 3 are shown the results obtained from beams 1 A-B-C, reinforced with three ¾-in. Ransome twisted bars, all placed horizontally and beams 2 A-B-C of similar dimensions and reinforcement except that the center bar is turned up at each end from a point 2 ft. 10 ins. inside the points of support.

An examination of these two sets of tests brings out three very interesting facts which might be called characteristic of beams reinforced in this manner, where the ratio of the depth of the beams to the length of the span is large.

(1) The average ultimate strength of beams 2 A-B-C with diagonal reinforcement was considerably more (57½%) than that developed in beams 1 A-B-C in which diagonal reinforcement was not used.

(2) A much greater variation in strength was found in the beams having no diagonal reinforcement; beams 1 A-B-C varying by 40% in the ultimate bending moments while beams 2 A-B-C showed a variation of but 2½%.

(3) The failure of beams 1 A-B-C occurred suddenly, while the diagonal reinforcement caused the failure crack to develop slowly in beams 2 A-B-C.

Fig. 4 gives the results obtained from tests of beams 3 A-B-C reinforced with seven ½-in. twisted bars, five of which are turned up at their ends, thus giving to these beams a large amount of diagonal reinforcement. The principal reason for the design of this beam was to determine whether there was any advantage in using small bars and a large amount of diagonal reinforcement in place of larger bars and a smaller amount of diagonal reinforcement.

It was expected that these beams, reinforced as they were against failure at either end, would fail in tension or compression. As a matter of fact, only one of them, 3 C, failed in this manner. The reasons for this are not difficult to determine after a careful study of the failure cracks. Beam 3 A failed suddenly in a crack which extended from one support to the nearest load, and apparently going directly through the diagonal reinforcing bars. After the beam was broken up it was discovered that all except the outer diagonal reinforcing bars had slipped down to the bottom of the beam and the failure crack extended just across their upper ends.

Beam 3 B shows a failure that was undoubtedly due to the slipping or pulling out of the diagonal rods. Fig. 5 shows a photograph of this beam as it appeared immediately after failure and before it had been removed from the testing machine. The concrete has failed up around the end shear bars. The photograph failed to bring out these shear bars, but that they are there can be seen by referring to Fig. 6, where another view of this beam is shown, with the broken concrete removed.

In beam 3-C the failure occurred in crack No. 1, which gradually opened up as the load was applied until the concrete finally crushed on top at the ultimate load.

These beams developed an average strength 13½% greater in proportion to their size than did beams 2 A-B-C, which was undoubtedly due to the additional diagonal reinforcement, aided perhaps by the higher elastic limit generally found in the ½-in. bars.

The character of the failure of beams 3-A and 3-B brings out clearly the necessity of extending shear bars as close up to the top of the beams as practicable, and also the necessity of having their ends carried back over the support far enough to prevent the bars from pulling out as occurred in 3-B.

Beams 4 A-B-C, reinforced with one 3¼ × 1¼ ins. Kahn bar, Fig. 7, all failed in a similar manner and at about the same loads. Tension cracks would gradually open up until the concrete failed in compression. In order to obtain a proper comparison between beams reinforced with this bar, and those reinforced with the corrugated and twisted bars, the design of 4 A-B-C should be materially changed. In the first place, two bars, having a high elastic limit and longer prongs, should have been used. At the time the bars used in these tests were purchased the Trussed Concrete Steel Co. did not to my knowledge manufacture a bar having a high elastic limit, or prongs longer than 18 ins. I understand this is not true at the present time, and I regret that the tests could not have been made with all of the reinforcing bars on a common basis. However, even as designed, the failure of beams 4 A-B-C was ideal in character, and from Table I. it will be seen that considerably more than the elastic limit of the steel was developed, which is all that could be desired, and all that can be said of any of the other bars, with the additional advantage that all of the failures were moment failures.

In beams 5 A-B-C and 6 A-B-C, Figs. 8 and 9, we have a comparison with corrugated bars similar to that obtained in beams 1 A-B-C and 2 A-B-C with twisted bars. Beams 6 A-B-C reinforced with five ¾-in. corrugated bars placed horizontally all failed suddenly in cracks extending from one support to the nearest load. Beams 5 A-B-C were of the same size as beams 6 A-B-C and similarly reinforced except that three of the bars were turned up at each end. Two of these beams, 5-B and 5-C, developed the full strength of the concrete in compression, while in the other, 5-A, the failure occurred slowly in a diagonal line at one end.

The facts brought out by the tests of beams 1 A-B-C and 2 A-B-C reinforced with twisted bars were in the main found to be equally true of beams 5 A-B-C and 6 A-B-C, reinforced with corrugated bars. Beams 5 A-B-C with diagonal reinforcement gave an average ultimate strength 46½% greater than that of beams 6 A-B-C without diagonal reinforcement. The maximum variation in ultimate strength was 12% in the former and 33% in the latter beams.

Figs. 10 and 11 shows the results obtained from beams 7 A-B-C and 8 A-B-C reinforced with three ⅞-in. round rods, all horizontal in beam 7 and one turned up at each end in beam 8. An attempt was made to prevent slipping by bending 3 ins. up 90° at each end of these round rods. The same sudden diagonal failure occurred in beams 7 A-B-C that was characteristic of the other beams reinforced with horizontal bars only. The variation in ultimate strength was also large.

Beams 8 A-B-C differing from all others, failed in tension cracks, the rods apparently slipping before the full strength of the concrete in compression was developed, indicating that the 3-in. bend at the ends was not a sufficient anchorage, against slipping at the ultimate load.

That the rods did slip in one case was shown by breaking away the concrete at one end of a rod, where an opening of about ¼-in. was found. Beams 8 A-B-C with diagonal reinforcement gave a 23% greater average ultimate strength than 7 A-B-C without diagonal reinforcement. The maximum variation in ultimate strength was 5% in the former and 42% in the latter beams.

Beams 9 A-B-C and 10 A-B-C are shown in Figs. 12 and 13. Three 1-in. corrugated bars were used for reinforcement, all horizontal in the former and with the center bar turned up at each end in the latter. All beams of both sets failed in a similar manner, diagonally from one support to the nearest load, except that in 10-C the diagonal bar seems to have pulled out the concrete shearing up around it, as is plainly shown in photograph Fig. 14.

Fig. 5.

Fig. 6.

FIGS. 5 AND 6. VIEWS SHOWING BREAK IN BEAM 3 B.

Beams 10 A-B-C with diagonal reinforcement gave an average ultimate strength 56% greater than the beams 9 A-B-C without diagonal reinforcement. The maximum variation in ultimate strength was 60% in the former and 20% in the latter beams. In beams 10 A-B-C the diagonal reinforcement was not sufficient to prevent a diagonal failure, although considerable more than the elastic limit of the steel was developed.

TABULATED RESULTS.—Fig. 12 shows the beams in detail and Table I. is a condensed tabulation of the results obtained from the tests. Columns 1, 2, 3, 4, 5 and 6 give general information relative to the make up of the beams. In designing beams 4 A-B-C, 5 A-B-C and 6 A-B-C it was intended that the same percentage of steel (0.75) should be used as was used in the others, but a slight error was made in locating the center of gravity of the steel in beams 5 A-B-C and 6 A-B-C, while in beams 4 A-B-C it was discovered after the tests had been made that the Kahn bar had an area of about 1.79 sq. ins. instead of 2.00 sq. ins. as catalogued. This area was obtained by taking an impression of the cross section and measuring with a planimeter. In Columns 7 and 8 are given the positions of the neutral axis, at the maximum load and at three-fourths of the maximum load, determined by plotting the deformations of the upper and lower fibers for beams "B" of the ten sets. Averaging up the values thus obtained, we find that, at the maximum load the distance from the top of the beam to the neutral axis to be about 34% of "d" for all grades of steel, "d" being the distance from the top of the beam to the center of the steel reinforcement. The maximum bending moment in inch pounds developed by each beam and the average for each set of three beams is given in Column 9.

In Columns 10, 11 and 12 are found the deformations of the concrete at the steel in inches per inch of steel, and the tensile stress in pounds per square inch, developed by the steel as calculated from the bending moments and that deduced from the observed extensions. The extension of the concrete at the steel does not represent the true extension of the steel, as there are elements of error introduced by the presence of cracks in the concrete, which, as the load increases, appear close to and at times directly under the contact points. It will be noticed that in all cases the stress in the steel as calculated from the bending moment is somewhat greater than that determined by the observed extensions. This is perhaps due in some cases to the fact that the extensometer apparatus was removed somewhat before the ultimate strength of the beams was reached and the deformation curves assumed as extending in a straight line from the last reading up to where the maximum moment occurred. This would not be the case where the steel had passed its elastic limit, but the diagram would commence to curve away from the straight line, thus giving a somewhat greater deformation than those used in the tables. Prof. Turneaure, in his experiments, found this same discrepancy, only in a much greater degree. He attributed a part of the difference to an initial tension in the rods caused by a change in volume of the concrete while setting.

Columns 13, 14 and 15 give the compression of the upper fiber of the concrete in inches per inch and the compressive stress as calculated from the bending moments and that deduced from the observed deformations and an assumed modulus of elasticity. This assumed modulus taken was the average modulus obtained by dividing the deformations of beams "B" into the compressive stresses as determined by the moments. In calculating the stress in the steel and concrete from the bending moments, the center of pressure of the compressive area was taken as 3/5 of the distance above the observed neutral axis. This is on the assumption that the stress strain diagram of concrete in compression closely approximates a parabola.

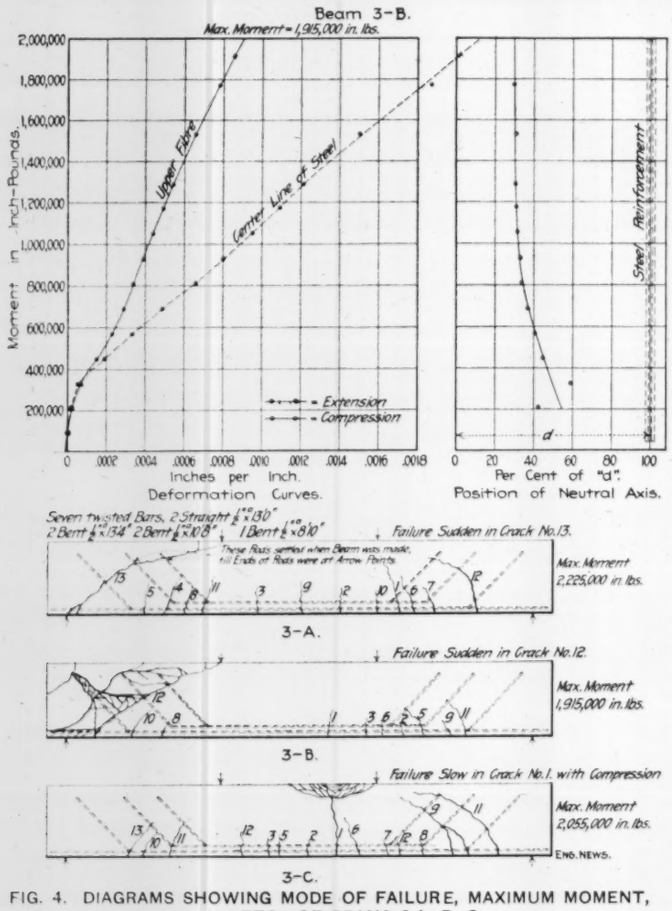

Beam 3-B.
Max. Moment = 1,915,000 in. lbs.
Moment in Inch-Pounds.
Upper Fibre.
Center Line of Steel.
Extension.
Compression.
Inches per Inch.
Deformation Curves.
Steel Reinforcement.
Per Cent of "d".
Position of Neutral Axis.
Seven twisted Bars, 2 Straight 1"x13'0"
2 Bent 1"x13'4" 2 Bent 1"x10'8" 1 Bent 1"x8'0"
These Rods omitted when Beam was made, till Ends of Rods were at Arrow Points.
Failure Sudden in Crack No. 13.
Max. Moment 2,225,000 in. lbs.
3-A.
Failure Sudden in Crack No. 12.
Max. Moment 1,915,000 in. lbs.
3-B.
Failure Slow in Crack No. 1. with Compression
Max. Moment 2,055,000 in. lbs.
ENG. NEWS.
3-C.

FIG. 4. DIAGRAMS SHOWING MODE OF FAILURE, MAXIMUM MOMENT, ETC., OF BEAMS 3 A, B, C.

Taking only those beams which have diagonal reinforcement and in which steel with a high elastic limit was used, it would seem from the tabulated results that the value of $M \div bd^2$ as derived by the formula could be increased until more nearly equal to Rbd^2 as determined by the tests. Although it is true that the values in column 19 represent the ultimate strength of the beams, still the beam when under a much greater load is destroyed for all practical purposes, on account of the large number of cracks which open up in the concrete. If this were not true it would be possible to design beams based upon the ultimate strength of the steel instead of the elastic limit. By having a sufficient amount of diagonal reinforcement so as to prevent an end failure, and by using a very rich mixture of concrete, or placing reinforcing bars in the top of the beam so as to prevent a compression failure, a beam could be designed that would develop the full strength of the steel. Long before the steel failed, however, cracks would have been opened up in the concrete to such an extent as to have destroyed the beam for all practical purposes.

ADOPTED FORMULA.—In determining the values of $M \div bd^2$ in column 20, an elastic limit of 54,000 lbs. per sq. in. was used for the twisted and corrugated bars and of 35,000 lbs. per sq. in. for the plain round and trussed rods. The effective depth is derived on the assumption that the stress strain diagram of the concrete in compression is approximately a parabola. With this assumption, and using an amount of steel equal to 0.75% of the area of the concrete above the steel, the formula for steel of 54,000 lbs. elastic limit is as shown in Fig. 15.

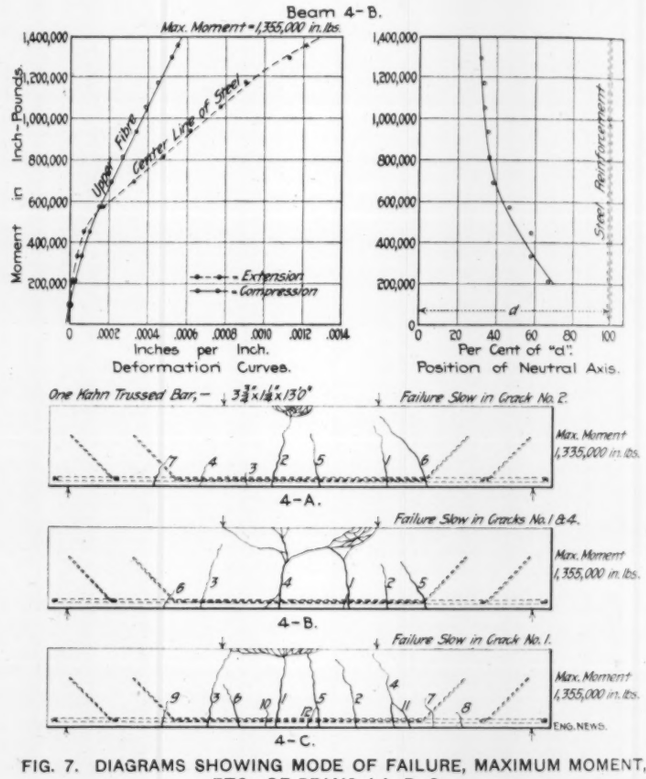


FIG. 7. DIAGRAMS SHOWING MODE OF FAILURE, MAXIMUM MOMENT, ETC., OF BEAMS 4 A, B, C.

The values given in Column 15 were worked out with the idea of fixing upon some value for the modulus of elasticity of concrete in compression that would give approximately the compressive values as determined from the moments and thus obtain a modulus that could be used in designing. It will be noticed that the modulus assumed and the measured deformations give compressive values that compare closely to those obtained from the moment except for the beams reinforced with high elastic limit steel, with one or more bars turned up at the ends. For these beams a higher modulus would have given closer results for some and a lower modulus for others.

In column 16 is given the maximum end shear in pounds; in column 17 the average unit vertical shear in pounds per square inch and in column 18 the maximum unit shear in pounds per square inch over the supports at the neutral axis, assuming that the stresses at that location are the same as those in a homogeneous beam. Column 19 gives values of $M \div bd^2$ derived from the test strength of the beams. These figures represent a true comparison of strengths between beams which are reinforced with equal percentages of steel of the same elastic limit. In column 20 are the values of $M \div bd^2$ as derived from the adopted working formula.

Equations 4 and 6 are all that are necessary to design a beam, and equation 5 to prove a beam where the above constants are used. It should be borne in mind that "M" in equation 6 represents the ultimate resisting moment and in designing a beam should be increased by the desired factor of safety.

By making F equal 35,000 in equation 5, a working formula for beams having 0.75% of steel of that elastic limit is obtained.

The values used for the percentage of the steel reinforcement and the elastic limit of the steel were fixed partly by practical considerations. Experience in the design of covers for flat top culverts has shown that for a heavy railroad structure where beams of 2 to 3 ft. thick are common, an amount of high elastic limit steel equal to about 0.75% of the area of concrete above the steel will give a spacing of bars about as close together as will allow of a safe transfer of stress from the concrete to the steel.

Where the steel reinforcement has an elastic limit as low as 35,000 lbs. per sq. in. the writer would advocate the use of an amount equal to between 1 and 1¼% of

the area of concrete above the steel. In other words, use an amount of low elastic limit steel that would give the same internal stresses in the beam as would be developed in a beam of equal dimensions reinforced with 0.75% of high elastic limit steel.

SUMMARY.—The writer has nothing to offer in the way of a method for determining the exact amount of diagonal reinforcement required in a given beam. The results of these tests, however, seem to show beyond a reasonable doubt that some reinforcement of this kind should be used at all times. Where the load to be sustained is light, and in addition a small percentage of steel is used, the unit shearing stresses are correspondingly small and there is but little danger of a diagonal failure. On the other hand, where large loads are to be sustained, as in railway structures, and where, in addition, a large percentage of high elastic limit steel is used, the unit shearing stresses become excessive and the satisfactory reinforcing of the beam against diagonal failure becomes exceedingly difficult.

After a careful consideration of the results obtained from the above tests, combined with practical experience, the writer has the following to offer in the way of conclusions:

1. An amount of high elastic limit steel equal to about 0.75% of the concrete above the steel is as much as can be economically used in beams sustaining heavy loads, and subjected to large shearing stresses.

2. Diagonal reinforcement should be used at the ends of all concrete beams, not only to develop the full elastic limit of the steel in beams where the unit shearing stresses are large, but to insure against faulty construction and the then liability of sudden failure in beams where the unit shearing stresses are small.

3. Diagonal reinforcing bars should be brought well up to the top of the beam and securely anchored against slipping.

4. The use of small bars is preferable for several reasons. The elastic limit is higher, they give a better distribution of the stresses, and they offer a better opportunity to obtain a satisfactory diagonal reinforcement. Also they are much easier to handle, and bend in the field.

5. The use of bars larger than 1 in. is particularly objectionable both from a practical and a theoretical standpoint.

6. The ultimate strength of a reinforced concrete beam for all practical purposes is reached at least as soon as the steel has been stressed up to its elastic limit.

7. The location of the neutral axis varies with the amount of steel and the class of the concrete. With an amount of steel equal to about 0.75% of the area of the concrete, and with an average class of concrete, the distance from the top of the beam to the neutral axis at rupture as determined by these tests is about one-third of the distance from the top of the beam to the center of the steel.

8. After obtaining the approximate location of the neutral axis it makes little difference whether the distance from the neutral axis to the center of the compressive area is taken as 2/3Y as in the case of the triangular area, or 3/5Y, as for a parabolic area. The difference in the resulting resisting moment being less than 3%.

9. Experimental methods are desirable for determining the position of the neutral axis, as it enables one to design a beam without making an assumption as to the modulus of elasticity of the concrete. If the neutral axis has been determined by experiment, and a class of concrete used that will develop the elastic limit of the steel, the value of the modulus of elasticity of the concrete is not essential.

10. The turning up of every other bar as in beams 2 and 10 is sufficient to prevent a diagonal failure before the elastic limit of the steel is reached, at least where the percentage of the steel reinforcement does not exceed that used in these tests, and where the elastic limit of the steel does not exceed about 60,000 lbs. per sq. in., provided that the beam is loaded uniformly or in such a manner as to closely approximate the conditions of a uniformly loaded beam.

The reader should bear in mind that these conclusions are not intended as being applicable to reinforced concrete in general, but are advanced as the writer's opinions as to what constitutes good practice and design where the conditions are similar to those under which these tests were made. One of the common errors in the study of reinforced concrete is the attempt to compare results which have been obtained from tests made by different investigators, apparently regardless of the wide variation in the conditions under which the tests have been made. Differences in the method of loading, the richness of the mixture, the amount and character of the reinforcement and the ratio of the depth of the beams to the length of the span, all tend to introduce new conditions which preclude the possibility of comparative results. The writer therefore wishes to emphasize the fact that these tests were made upon beams designed for specific conditions, and that the conclusions drawn are intended to apply only to beams subject to these conditions.

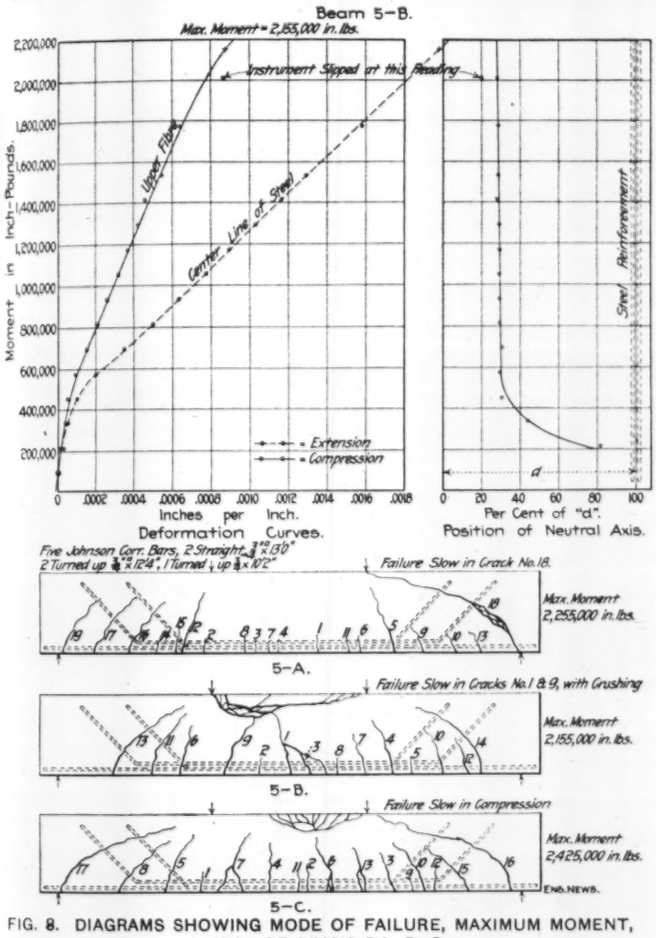


FIG. 8. DIAGRAMS SHOWING MODE OF FAILURE, MAXIMUM MOMENT, ETC., OF BEAMS 5 A, B, C.

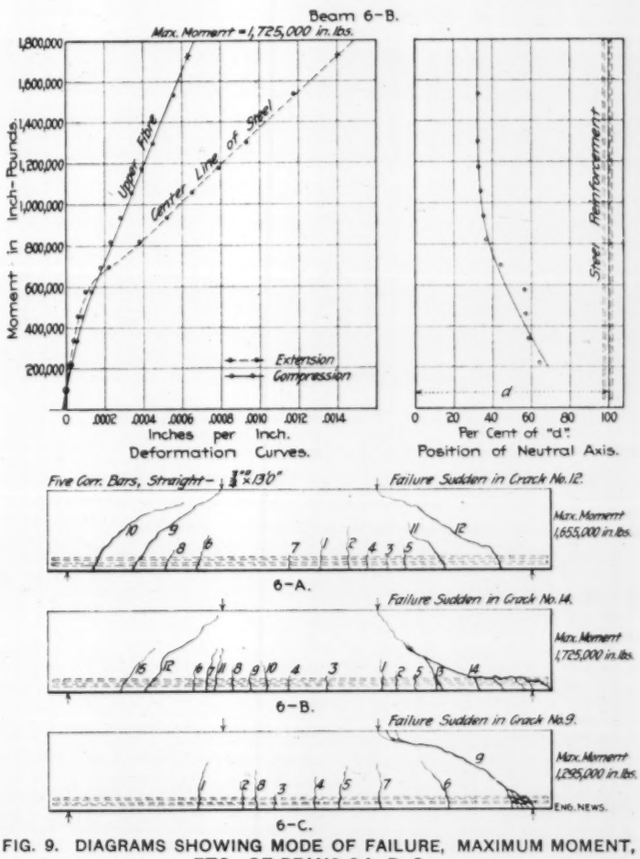


FIG. 9. DIAGRAMS SHOWING MODE OF FAILURE, MAXIMUM MOMENT, ETC., OF BEAMS 6 A, B, C.

DISCUSSION.

By Prof. A. N. Talbot.*

In beginning the discussion of the paper, it may not be out of place to refresh your minds with a brief review of the various sources or methods of failure in reinforced concrete beams. We want to find the cause of the primary failure, using this term to express the first decided change in the action of the beam causing changes which bring in entirely new conditions and this primary failure may or may not be the same as the cause of ultimate failure. A reinforced concrete beam may fail by one or more of the following methods: (1) Tension of steel; (2) compression of concrete; (3) shearing of concrete; (4) diagonal tension; (5) slip of bars (bond); (6) miscellaneous methods, like the splitting off of bars away from concrete, effect of bearings, etc. Which one of these methods of failure will govern the strength of a beam is dependent upon percentage of reinforcement, kind of steel, quality of concrete, relation of depth to length, disposition of reinforcement, and other circumstances. Generally, for a given beam we may narrow down the number to two or three methods of failure without much calculation.

(1) TENSION OF STEEL.—Beams with shallow depth as compared with their length and with a moderate amount of reinforcement with usual loading may be expected not to fail before the steel has been stressed to its yield point. A still greater load will cause the steel to stretch much more rapidly than before, the neutral axis will rise, the 'compression area'' of the beam will be reduced, and the compressive stress in the top fiber will rapidly increase, until the beam is likely to fail by compression in the top of the beam at a load but little beyond that at which the yield point of the steel was exceeded. While compression of concrete may cause ultimate failure of the beam, the primary cause of failure and the one which should be considered, is the failure of the steel in tension by passing its yield point. When deformations are measured, the plotted curve will show a sudden and marked change when the steel of the beam has reached its yield point.

(2) COMPRESSION OF CONCRETE.—Beams having a large amount of reinforcement may fail through the crushing of the concrete at the top of the beam before the steel has been stressed to its elastic limit. For good concrete and with steel having an elastic limit of 35,000 lbs. per sq. in. this form of failure may not be

*Professor of Municipal and Sanitary Engineering, University of Illinois, Champaign, Ill.

TABLE I.—SHOWING RESULTS OF TESTS OF REINFORCED CONCRETE BEAMS MADE BY THE CHICAGO, MILWAUKEE AND ST. PAUL R. R.

Beam.	GENERAL INFORMATION: Distance from c. of steel to comp. surf. Ins. "d"	Number and size of bars.	Kind of bar.	Method of placing reinforcement.	Per cent. longitudinal reinforcement. %	Position of neutral axes: At ½ maximum load. % of "d" from comp. surface.	Position of neutral axes: At maximum load. % of "d" from comp. surface.	Maximum moment at time of failure. Inch. pounds.	EXTENSION (At maximum load.): Extension of concrete at c. of steel. Inches per in.	Tensile stress in steel. From moment. Lbs. per sq. in.	Tensile stress in steel. From extens. Lbs. per sq. in.	COMPRESSION (at maximum load.): Compression of extreme fiber of concrete. Ins., per inch.	Compressive stress in concrete. From moment. Lbs. per sq. in.	Compressive stress in concrete. From comp. Lbs. per sq. in.	SHEAR (at maximum load.): Maximum end shear, pounds.	Average unit vert. shear. Lbs. per sq. in.	Maximum unit shear. Lbs. per sq. in.	COMPARISON of "M" / b d²: From tests.	From adopted formula.	REMARKS.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
1-A	18¼	3-¾	Ransome	All straight.....	0.75	....	...	900,000	.....	32,900	.....	.....	1,160	.....	19,160	85	128	212.5	350.0	Diagonal failure, sudden
1-B	"	"	"	" "	"	31	34	995,000	0.00105	36,300	31,500	0.00048	1,280	1,155	21,160	94	141	235.5	"	" " "
1-C	"	"	"	" "	"	....	...	1,265,000	.....	46,300	.....	.....	1,630	.....	26,660	118	178	299.0	"	Diagonal failure, sudden with hor. shear at bar
Ave.	"	"	"	" "	"	....	...	1,053,000	.....	38,500	.....	.....	1,360	.....	22,325	99	149	249.0	"	
				Two stright,																
2-A	"	"	"	one turned up...	"	....	...	1,650,000	.....	61,000	.....	.....	2,020	.....	34,660	155	233	389.5	"	Diagonal failure, slow
2-B	"	"	"	" " ...	"	35	36	1,685,000	0.00201	62,100	60,300	0.00113	2,070	2,700	35,410	157	236	398.0	"	" "
2-C	"	"	"	" " ...	"	....	...	1,645,000	.....	60,600	.....	.....	2,015	.....	34,560	154	231	389.0	"	" "
Ave.	"	"	"	" " ...	"	....	...	1,660,000	.....	61,200	.....	.....	2,035	.....	34,875	155	233	392.0	"	
				Two straight,																
3-A	19⅜	7-⅛	"	five turned up...	"	....	...	2,225,000	.....	75,000	.....	.....	2,910	.....	46,775	193	290	452.0	"	Diagonal failure, sudden
3-B	"	"	"	" " ...	"	30	31	1,915,000	0.00204	64,200	61,200	0.00087	2,500	2,090	40,275	173	260	425.0	"	" "
3-C	"	"	"	" " ...	"	....	...	2,055,000	.....	69,100	.....	.....	2 685	.....	43,225	186	280	456.0	"	Crack ran along inch.
Ave.	"	"	"	" " ...	"	....	...	2,065,000	.....	69,400	.....	.....	2,700	.....	43,425	184	277	444.5	"	Compression and tension failure, slow
				Standard Kahn bar,																
4-A	22	1-3½x1¼	Kahn	two pair of bends.	0.68	....	...	1,335,000	.....	39,200	.....	.....	1,250	.....	28,225	107	161	230.0	205.0	Tension failure, slow
4-B	"	"	"	" " " .	"	31	34	1,355,000	0.00123	39,750	36,900	0.00057	1,270	1,365	28 675	109	163	232.5	"	slight compression, slow
4-C	"	"	"	" " " .	"	....	...	1,355,000	.....	39,750	.....	.....	1,270	.....	28,675	109	163	232.5	"	" " "
Ave.	"	"	"	" " " .	"	....	...	1,348,300	.....	39,600	.....	.....	1,265	.....	28,525	108	162	232.0	"	" " "
				Two straight,																
5-A	21⅞	5¾	Johnson	three turned up....	0.72	....	...	2,255,000	.....	64,300	.....	.....	2,545	.....	47,425	184	276	407.5	334.0	Diagonal failure, slow
5-B	"	"	"	" "	"	28	29	2,155,000	0.00199	61,300	59,700	0.00089	2,435	2,140	45,275	176	264	389.5	"	Com. fail. slow, with ten.
5-C	"	"	"	" "	"	....	...	2,425,000	.....	69,000	.....	.....	2,730	.....	50,925	197	296	438.0	"	Compression failure, slow
Ave.	"	"	"	" "	"	....	...	2,278,300	.....	64,900	.....	.....	2,570	.....	47,875	186	279	412.0	"	
6-A	"	"	"	All straight.....	"	....	...	1,655,000	.....	48,000	.....	.....	1,670	.....	34,925	136	205	299.0	"	Diagonal failure, sudden
6-B	"	"	"	" "	"	32	33	1,725,000	0.00142	50,000	42,600	0.00065	1,740	1,560	36,425	142	212	312.0	"	" " "
6-C	"	"	"	" "	"	....	...	1,295,000	.....	37,500	.....	.....	1,310	.....	27,425	107	160	234.5	"	" " "
Ave.	"	"	"	" "	"	....	...	1,558,300	.....	45,200	.....	.....	1,570	.....	32,925	128	192	282.0	"	
				All straight,																
7-A	20	3-⅞	Plain round	(anchored)	0.75	....	...	1,169,000	.....	37,800	.....	.....	1 295	.....	24,775	103	155	243.5	226.0	Diagonal failure, sudden
7-B	"	"	"	" "	"	33	35	1,463,000	0.00124	47,300	37,200	0.00034	1,625	1,540	30,875	129	194	305.0	"	" " "
7-C	"	"	"	" "	"	....	...	1,025,000	.....	33,100	.....	.....	1,130	.....	21,775	91	137	213.0	"	" " "
Ave.	"	"	"	" "	"	....	...	1,219,000	.....	39,400	.....	.....	1,350	.....	25,810	108	162	254.0	"	
				Two straight, one																
8-A	"	"	"	bent (anchored)...	"	....	...	1,505,000	.....	48,300	.....	.....	1,705	.....	31,775	132	199	313.5	"	Tension failure, slow
8-B	"	"	"	" " ...	"	34	34	1,529,000	0.00136	49,100	40,800	0.00067	1,735	1,610	32,275	135	202	318.5	"	" " "
8-C	"	"	"	" " ...	"	....	...	1,460,000	.....	46 800	.....	.....	1,650	.....	30,875	129	193	303.5	"	" " "
Ave.	"	"	"	" " ...	"	....	...	1,498,000	.....	48,100	.....	.....	1,695	.....	31,640	132	198	312.0	"	
9-A	23¼	3-1	Johnson	All stright.....	"	....	...	1,658,500	.....	39,800	.....	.....	1,290	.....	35.025	126	189	255.0	350.0	Diagonal failure, sudden
9-B	"	"	"	" "	"	35	37	1 875,000	0 00122	45,000	36,600	0.00065	1,460	1,560	39,525	142	213	288.0	"	" " "
9-C	"	"	"	" "	"	....	...	1,565,000	.....	37,500	.....	.....	1,215	.....	33,025	119	178	241.0	"	" " "
Ave.	"	"	"	" "	"	....	...	1,699,000	.....	40,750	.....	.....	1,320	.....	35,860	129	193	261.0	"	
				Two straight,																
10-A	"	"	"	one turned up....	"	....	...	2,585,000	.....	61,750	.....	.....	2,060	.....	54,375	195	293	397.0	"	Diagonal failure, sudden
10-B	"	"	"	" "	"	35	36	2,738,500	0.00191	65,400	57,300	0.00108	2,180	2,590	57,525	207	311	421.5	"	" " "
10-C	"	"	"	" "	"	....	...	2,625,000	.....	62,800	.....	.....	2,100	.....	55,025	198	297	404.0	"	Diag. fail., sudden, craked along inclined bars
Ave.	"	"	"	" "	"	....	...	2,649,500	.....	63,300	.....	.....	2,110	.....	55,640	200	300	407.5	"	

NOTES:—

Column No. 2 —In beams Nos. 3, 5 and 6, where two layers of bars are used, "d" is taken as the distance from the center of gravity of steel to the compression surface.
" " 4 —All Johnson corrugated bars used, were of "old-style" section.
" " 6 —Per cent. longitudinal reinforcement is computed with respect to section above c. of steel.
" " 9 —Moment due to weight of beam is included.
Columns Nos. 10 and 13—Deformation due to weight of beam is included.
" " 11 and 14—Computed by adopted formula from columns Nos. 8 and 9.
Column No. 12 —Modulus assumed to be 30,000,000 lbs. per sq. in.
" " 15 —" " " " 2,400,000 lbs. per sq. in.
" " 17 —"Average unit vertical shear" = total end shear ÷ the area of the section of beam above c of steel.
" " 18 —"Maximum unit shear" is the unit shear at neutral axis, directly over the supports—Stresses over the support are assumed to be the same as in a similar homogeneous beam.
" " 20 —Unit stress in steel assumed as 54,000 lbs. per sq. in. in Johnson and Ransome bars, and 35,000 lbs. per sq. in. in Kahn and plain round bars—"y," assumed as being 34% of "d".

expected if the reinforcement is not more than 1½%; nor with steel of 60,000 lbs. elastic limit if the reinforcement is less than 1%. These percentages are not given as exact quantities. If diagrams of deformations are made, the curve showing shortening of the upper side of the beam will curve away before the crushing point is reached.

(3) SHEARING OF CONCRETE.—The ordinary assumptions used in the mechanics of beams give horizontal shearing stresses and vertical shearing stresses of equal intensity at any point in a beam, and these vary in amount in different portions of the depth of the beam. These horizontal stresses may be said to transmit the tension of the steel to the compression of the concrete. In homogeneous rectangular beams, like wooden beams, the maximum unit shearing stress, either horizontal or vertical, occurs at the neutral axis and equals $V \div bd \times 3/2$, where V is the external or vertical shear at the given section, and b and d the breadth and depth of the beam. It may be shown for the assumptions used in the ordinary theory of beams that the maximum unit shear is $V \div bd'$, where d' is the distance from the center of the compressive stresses to the center of the tensile stresses, and which we may call for convenience the effective depth of the beam. If we disregard tension in the concrete, the unit shear in a reinforced concrete beam will be constant from the steel to the level of the neutral axis, and for the beams described to-night will be about $V \div 0.87bd$. The diagram is intended to show the distribution of the shearing stresses through a vertical section. Of course, this reasoning applies to cases where the reinforcement is carried horizontally to the end of the beam, and must be modified where bars are bent into inclined positions.

The shearing stresses obtained by calculation in this way are small in amount, and the limit usually put on the resistance of the concrete is quite low. However, it is ordinarily stated in books, I believe, that the shearing strength of concrete is, say, 15% of its crushing strength, as sometimes given, to as high as 35%. Values like these are obtained from tests where bending action controls and where the failures are really tension failures. The real shearing strength of concrete is greater than these results imply. Tests made at the University of Illinois on test pieces designed so that tensile stresses will not govern, indicate that shearing strength is as much as half to three-fourths as great as the compressive strength. With this view of it, it can hardly be said that reinforced concrete beams ordinarily fail by shear. What we have been calling shearing failures are really tension failures.

(4) DIAGONAL TENSION.—Shearing stresses in beams necessitate corresponding diagonal tensile and compressive stresses. The theory of beam action shows that the combination of shear and tension or compression forms tensile or compressive stresses in every direction, the direction and amount of the maximum forces varying with the relation of the values of these two forces. By the theory the value of the maximum diagonal tensile unit stress is $t = \frac{1}{2}f + Vv^2 + \frac{1}{4}f^2$, where f is the horizontal tensile unit stress at the point considered and v is the horizontal or vertical unit shearing stress. For the space between the steel reinforcement and the neutral axis, if we consider the concrete of the beam is not subject to horizontal tension, the value of this diagonal tension is greatest at an angle of 45° with horizontal, and the tensile unit-stress or intensity at 45° is by this method of analysis just equal to the horizontal or vertical unit-shear at that point, which by the previous formula is $V \div bd'$. If the horizontal tension existing in the concrete just below the neutral axis is considered, the diagonal tension will be found to be greater than this, bringing the value of the maximum tension to nearly double the results of this formula. However, as we do not know the amount of this and as even the distribution of these stresses is evidently not exactly as assumed, it may be well enough for our purpose to make use of the formula $V \div bd'$ and to compare calculations made on this basis for beams failing by diagonal tension.

When the reinforcement is placed in a horizontal position throughout the length of the beam, this diagonal tension is taken by the concrete. Whenever the dimensions of the beam are such as to make the diagonal tensile stress as calculated by the formula $V \div bd'$ more than, say, 125 or 150 lbs. per sq. in. (the limit depending upon the strength and age of the concrete) the beam may fail by diagonal tension failures, commonly called shear failures, and these failures are characterized by sudden breaks, without much warning, as is the case in the failure of plain concrete beams, quite in contrast with the slow failure by steel being stretched beyond its elastic limit or by crushing of concrete.

Since this diagonal tension may be resolved into horizontal and vertical or other components, the concrete may be relieved of a part or all of this diagonal tensile stress by one of two means: (1) By bending the reinforcing rods into a diagonal position, and, (2) by making use of vertical stirrups to take the vertical component of the diagonal tension. The efficacy of these two methods depends upon the method of loading used and upon the system of reinforcing. Sometimes both are used. The calculations for proportioning for the two methods need not be entered into here.

It is evident, since the vertical or external shear is independent of the bending moment, that the relation between the depth and length of a beam will determine whether precautions to reinforce for these stresses are necessary, and that in relatively deep and short beams diagonal tension may fix the strength of the beam, while in shallow and long beams it may be disregarded.

(5) BOND BETWEEN STEEL AND CONCRETE.—To enable the tension in the steel to be taken off, so to speak, shearing or stripping forces act between the surface of the steel and the surrounding concrete, and the resistance to this stripping is commonly known as bond. The amount of this bond developed at any point in a reinforcing bar may be expressed in lbs. per sq. in. of the surface of the bar. For beams with the bars extending horizontally for the full length of the beam, the value of the bond developed at any point may be calculated as $V \div nod'$, where V is the total vertical shear as before, n is the number of bars, o is the periphery of a bar and d' is the effective depth as before. Bond tests with

plain steel rods give values from 300 to 600 lbs. per sq. in., but it is not certain what amount may be relied upon in beams. The value of the resisting bond will depend not only upon the smoothness of the surface of the bar, but upon the uniformity of its diameter. Rods of tool steel smooth and very uniform in section slipped in beam tests when only 90 lbs. per sq. in. of bond had been developed. However, with ordinary steel bars placed horizontally and with good concrete, it is likely that diagonal tension failure will result before any slipping of bars will take place. When bars are bent diagonally but kept in the same plane, the formula here given may still be used. It will be seen that in this case d' will decrease and hence the demand on the bond resistance will increase toward the end of the bars. When the bars are bent at different points in their length, the amount of the bond is less determinate.

(5) MISCELLANEOUS METHODS.—Certain failures, like the splitting off of the bars from the upper concrete, or effect of spacing bars too closely, or with not sufficient concrete below the bars, need to be looked out for, and failures from these sources should be avoided.

Of course, in the foregoing review, reference is made to the ordinary simple beam, free from end restraints and with reinforcement only at the bottom of the beam. It would not be difficult to extend the reasoning to other conditions.

not be developed in the steel, and hence that anchorage cannot be brought into service until the bar has had an opportunity to elongate. If this portion of the bar does not elongate, the anchorage will not be brought into action, though it may be advantageous as a precautionary measure to prevent sudden failure in case of faulty construction.

These statements will perhaps help to clear the way and make it unnecessary to give more than a short discussion of the paper.

The amount of diagonal tension in the beams having the reinforcing bars straight or horizontal throughout, as calculated by the formula heretofore given, ranges from 125 to 150 lbs. per sq. in. This calculated value is all that concrete of this quality may be expected to resist in a beam of this kind, and their failure at stresses well within the elastic limit of the steel might have been predicted. When diagonal tension is taken entirely by the concrete, the resulting failure may be expected to be sudden, as tension failures of concrete are found to be.

In the beams with the bars bent into diagonal positions, the inclined bars take a considerable amount of the diagonal tensile stress. In some of these tests they have taken about all we could expect of them, possibly may have been stressed beyond the elastic limit of

should extend well into the compressive area, what is there in the tests of Beams 3 A and 3 B to show the necessity of extending the bars closer to the top or of anchoring their ends? Would not the design be improved by making the angle of the inclination less and thus reducing the stresses near the end of the bars? Reference is made to anchorage. How may anchorage be made effective unless high stresses exist up to the point of that anchorage? In what way may the anchorage in Beams 7 be expected to act? In conclusion 3 is it not meant that there should be sufficient bond resistance to take the stresses?

The calculation of the stresses in such beams and a comparison with observed results is an interesting matter. I do not know just how the measurements were made, but if the full weight of the beam is included in the moments, it must be remembered that after the extensometer readings were begun a part of the weight of the beam which at first produced tension in the lower part of the concrete goes, after the failure of the concrete in tension, to increase the tension in the steel, and should be included. I do not see that this has been taken into account. The values of the compression developed in the concrete as given in the calculations seem extremely high—larger than were likely developed. The

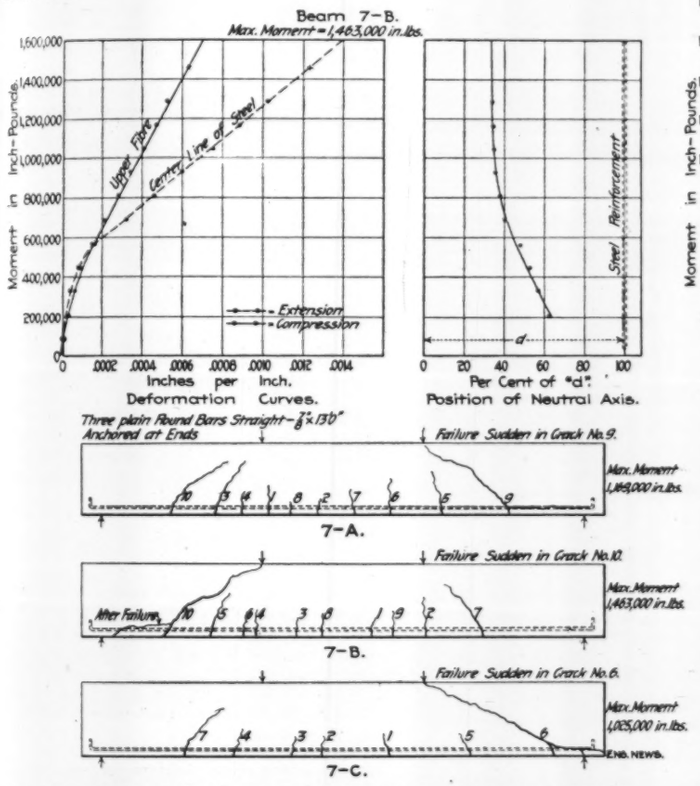


FIG. 10. DIAGRAMS SHOWING MODE OF FAILURE, MAXIMUM MOMENT, ETC., OF BEAMS 7 A, B, C.

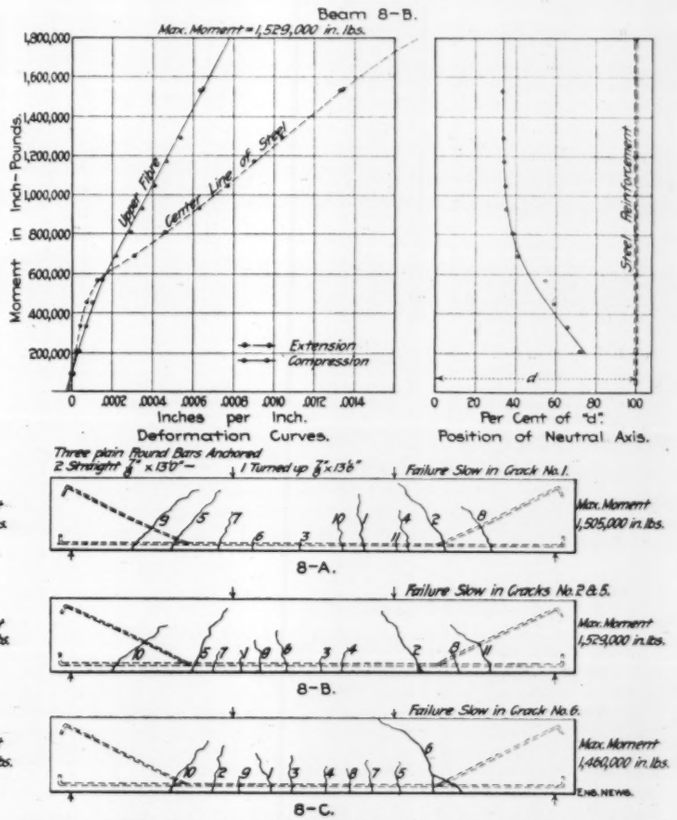


FIG. 11. DIAGRAMS SHOWING MODE OF FAILURE, MAXIMUM MOMENT, ETC., OF BEAMS 8 A, B, C.

It is evident, then, that to know which one of the foregoing methods will cause failure one must know the conditions entering into the problem—the relation of depth of beam to length, the percentage of reinforcement, the elastic limit of the steel, the quality of the concrete, etc.

In judging of the results of tests, a distinction must be made between primary failure and ultimate failure. Some change or failure may occur during the test which will greatly modify the condition in the beam, and we may not properly judge of the condition at this time by what happens later. This early or critical failure I am calling the primary failure, and this is the one which should be considered the cause of the failure of the beam. Reference has already been made to the passing of the elastic limit of the steel in some beam tests as the real or primary failure, instead of the crushing of the concrete which comes after the steel stretches considerably. In the same way, slipping of bars may come after diagonal tension failure has occurred. Much trouble has been made by experimenters reporting methods of ultimate failure as primary failure.

Again, it should be borne in mind that stress cannot exist in steel without stretch, and conversely that if there is no opportunity for stretch, the given stress will

the bar or may have reached the full amount of the bond and have begun to slip. For relatively deep beams, then, and with the amount of reinforcement used in these beams, some method of taking the diagonal tension other than by the concrete alone is necessary, and bending the rods diagonally is shown to be quite efficient. How far this method of diagonal reinforcement may be developed, and how it compares with vertical reinforcement would be interesting questions for discussion. Mr. Harding's final statement must be taken as referring to his beams, for shorter beams with the same reinforcement would probably have diagonal failures. The statement that the beams with bars inclined hold, say 50% more than those with bars straight, must be understood not to be applicable to beams of other dimensions.

In places in the paper, it would seem that the form of statement was not carefully made. Beam 3-C is said to have had the full compressive strength of the concrete developed, and the implication is that the Kahn beams (4, A, B, C) failed by crushing of the concrete. Evidently the primary cause of failure was something else. I take it, too, that the statement that it would have been better to have had longer prongs in the Kahn bars is a matter of judgment rather than a result shown by the tests. While, of course, diagonal reinforcement to be effective

position of the neutral axis seems high also, and one wonders at the cause of it. Mr. Harding uses the full parabola for the compression curve whether the maximum stress is 1,100 or 2,700. Although the value of the resisting moment may be closely calculated for beams in which yield point of steel controls if the neutral axis is known, regardless of the distribution of the compressive stresses, yet a knowledge of the modulus of elasticity would be advantageous in determining the position of the neutral axis and in determining the maximum stress in the concrete. In formulas for resisting moment it would seem that the term $y_2 + 35y_1$ could well be replaced by d $(1-2/5y_1)$. This is similar to the forms given in the paper in the Journal for August, 1904. Of course, the statement on page 19 that "equations 4 and 6 are all that are necessary to design a beam" refers to resisting moment of the steel, and it is not intended that shear, diagonal tension and bond resistances are not to be considered.

In this discussion I have taken up these points to add a word of limitation of the statements and in order that the results of the tests may not be misunderstood by those not well versed in the analysis, and I think Mr. Harding will generally agree with these interpretations. This construction is new and every effort should be made

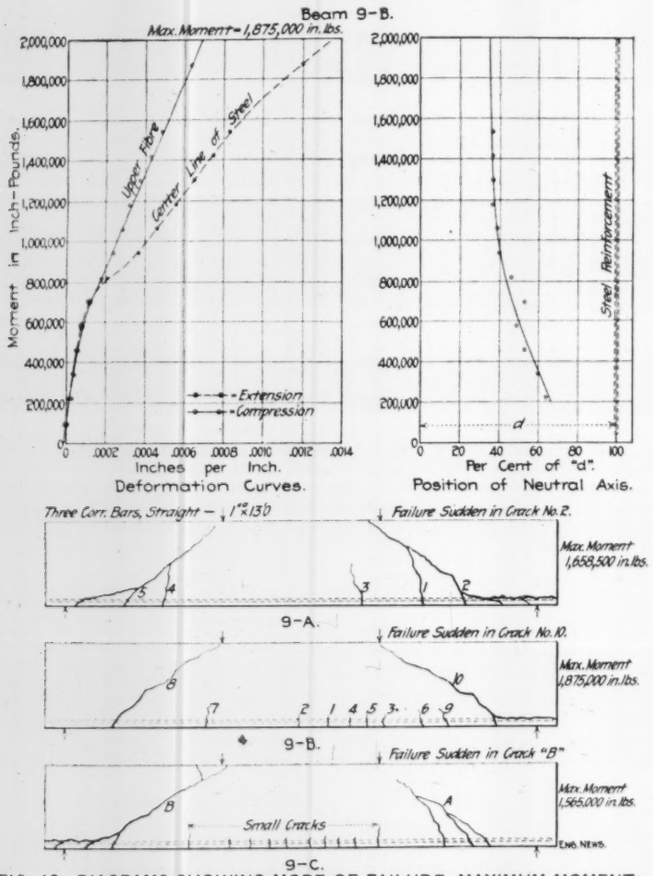


FIG. 12. DIAGRAMS SHOWING MODE OF FAILURE, MAXIMUM MOMENT, ETC., OF BEAMS 9 A, B, C.

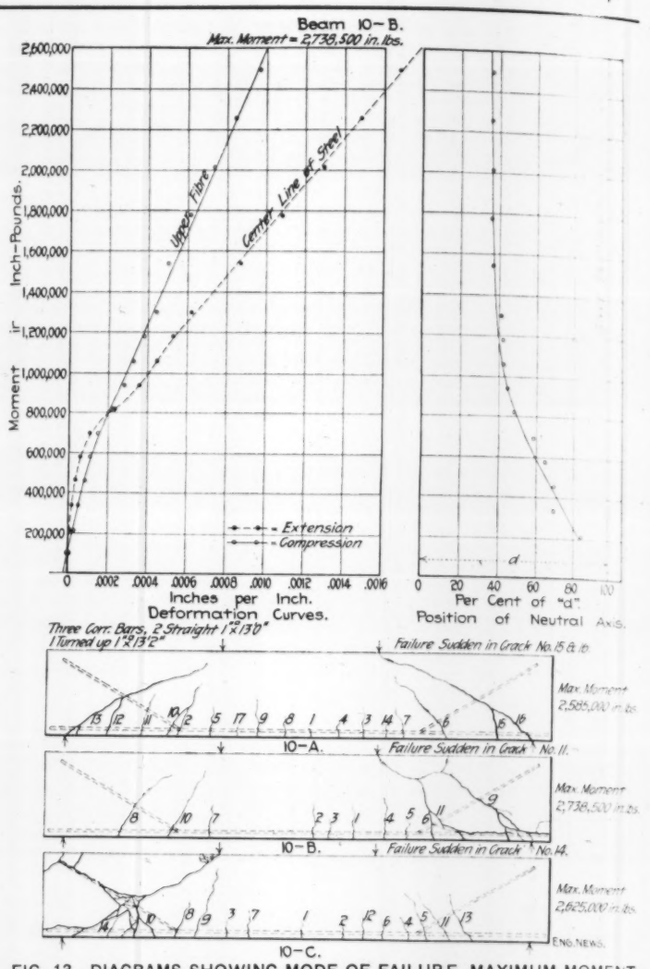


FIG. 13. DIAGRAMS SHOWING MODE OF FAILURE, MAXIMUM MOMENT, ETC., OF BEAMS 10 A, B, C.

to prevent any misconceptions of the nature of the beam action. Such tests as reported to-night are of great value in furnishing data for the design of reinforced concrete beams.

THE TESTS OF LOCOMOTIVES AT THE ST. LOUIS EXHIBITION, 1904.

One of the most important technical results of the St. Louis Exhibition of 1904 has recently appeared in the shape of the complete report of the tests made on the locomotive testing plant installed as a part of the exhibit of the Pennsylvania R. R. This plant was described in our issues of Nov. 26, 1903, and May 19, 1904, and an abstract of the official report of the first test was published in our issue of April 20, 1905. The plant was designed by Mr. A. S. Vogt, Engineer of Tests of the Pennsylvania R. R. under the direction of Mr. Theodore N. Ely, Chief of Motive Power, and Mr. A. W. Gibbs, General Superintendent of Motive Power. The advisory committee which had charge of the operation of the plant included in its resolutions of appreciation of the work of the staff, a resolution to Mr. Vogt "for a design of testing plant of unusual beauty and perfection of details, and of such excellence in operation that under severe conditions of service interruptions were more frequently due to locomotive defects than to difficulties with the plant."

The officials representing the Pennsylvania System in connection with the operation of this plant were as follows: J. J. Turner, Third Vice-President; Theo. N. Ely, Chief of Motive Power; F. D. Casanave, Special Agent; and G. D. Nelson, Engineer of Tests. The advisory committee above referred to was composed of the following members: Prof. W. F. M. Goss, Dean of the Schools of Engineering, Purdue University; J. E. Sague, First Vice-President of the American Locomotive Co.; Edwin M. Herr, General Manager of the Westinghouse Air Brake Co.; F. H. Clark, General Superintendent of Motive Power of the Chicago, Burlington & Quincy Ry.; C. H. Quereau, Superintendent of Shops, New York Central & Hudson River R. R.; H. H. Vaughan, Superintendent of Motive Power of the Canadian Pacific Ry.; H. V. Wille, Assistant Superintendent of the Baldwin Locomotive Works; W. A. Smith, Chief of the Department of Transportation Exhibits (St. Louis Exhibition). The first three were appointed by the American Society of Mechanical Engineers, and the next three by the American Railway Master Mechanics' Association.

There were eight locomotives tested, and the complete reports of the individual tests, with tables, diagrams, etc., occupy some 560 pages, while detail drawings are given of all the engines. The report in all comprises over 700 pages, with over 800 illustrations in the way of drawings and diagrams. Space does not permit of any extended particulars of the several tests, but from the various records we have compiled the accompanying table which presents some of the special features for purposes of comparison. The upper part of the table gives the general particulars of the engines, while in the lower part are given the main results of the performance at two speeds for each engine. We also present some of the general information from that part of the report dealing with the comparisons and conclusions based upon the series of tests. The engines tested (with the dates on which they were described in Engineering News) were as follows:

Freight Locomotives:

1. Pennsylvania R. R.: Simple consolidation (2-8-0). Built at the railway shops. Engineering News, April 20, 1905.

FIG. 14. VIEW OF BEAM 10 C, SHOWING POSITION OF CRACKS.

2. Lake Shore & Michigan Southern Ry.: Simple consolidation (2-8-0). Built at the Brooks works of the American Locomotive Co.

3. Michigan Central Ry.: Two-cylinder cross-compound consolidation (2-8-0). Built at the Schenectady works of the American Locomotive Co.

4. Atchison, Topeka & Santa Fe Ry.: Four-cylinder, tandem-compound, double-end decapod (2-10-2). Built by the Baldwin Locomotive Works. Engineering News, Oct. 6, 1904.

Passenger Locomotives:

5. Atchison, Topeka & Santa Fe Ry.: Four-cylinder balanced compound (Vauclain system), Atlantic (4-4-2).

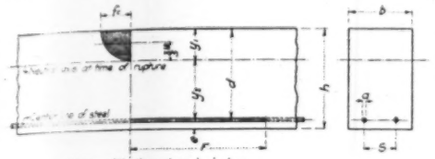


Fig. 15. Diagram of Beam Formula.

Built by the Baldwin Locomotive Works. Engineering News, March 31, 1904.

6. New York Central & Hudson River Ry.: Four-cylinder balanced compound (Cole system), Atlantic (4-4-2). Built by the American Locomotive Co. Engineering News, June 23, 1904.

7. Prussian State Railways: Four-cylinder balanced compound (Von Borries system), Atlantic (4-4-2). With Pielock superheater. Built by the Hannoversche Maschinenbau Actien-Gesellschaft, Hannover, Germany. Engineering News, Nov. 24, 1904.

8. Pennsylvania R. R.: Four-cylinder balanced compound (De Glehn system), Atlantic (4-4-2). Built by the Societe Alsacienne de Constructions Mecaniques, Belfort, France. Engineering News, March 31 and May 26, 1904.

COMPARISON OF BOILERS.

All the locomotives (with the exception of No. 4) were at some time during the tests worked to the limit of boiler capacity, measured in terms of equivalent. evaporation per sq. ft. of fire heating surface per hour; these rates of evaporation were maintained for at least one hour. The boiler of No. 6 had the highest capacity, over 16 lbs. of water per sq. ft. of water heating surface; that of No. 8 had a capacity of about 15½ lbs. if the surface of the ribs of the Serve tubes is omitted.

The relative advantages of large and small grates were not definitely settled, but the results are held as conclusive in proving that the furnace losses due to excess air are not greater with the large grate (when properly fired) than with the smaller grate. Engines Nos. 2 and 4 had relatively small grates, and for equal rates of combustion per sq. ft. of grate, their capacity was distinctly less than the boilers with larger grates. Engines Nos. 3 and 6 had much less firebox heating surface than the others, and it appears that there was no special advantage in large firebox heating surface; it is stated that probably the tube heating surface, if ample, will absorb the heat not taken up by the firebox. The two foreign locomotives (Nos. 7 and 8) had copper fireboxes, but no advantage in economy or capacity can be traced to this cause.

In regard to the maximum and minimum firebox and smokebox temperatures obtained, a comparison of these results with stationary practice will show that there is no excessive loss of heat due to high smokebox temperature, even at the higher rates of combustion, and the smokebox temperatures obtained when the locomotives were working at the average horse-power show very satisfactory results as compared with stationary work. There is a great variation in boiler efficiency at varying rates of combustion, and in all cases the highest efficiency is obtained with the smallest (or nearly the smallest) HP., and the efficiency rapidly decreases as the HP. is increased. The results show conclusively the desirability of large boiler capacity in relation to the average work expected from the locomotive. An examination of the efficiencies in connection with the HP. developed shows that the locomotive boiler compares favorably in efficiency with good stationary practice, while capable of developing large overload HP. for emergencies, at a sacrifice of economy.

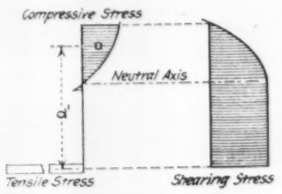


FIG. 16.

It is shown that a brick arch of proper size will make possible a higher firebox temperature and thus decrease the percentage of carbonic monoxide, but in the majority of boilers tested the losses due to imperfect combustion of carbonic monoxide were not serious. Locomotives Nos. 2, 5 and 6 had self-cleaning front ends, and the results showed that this arrangement offers considerable resistance to the passage of the gases. The two foreign engines, Nos. 7 and 8, required less draft per lb. of coal than any of the other engines, probably on account of the absence of obstructions in the smokeboxes.

The steam delivered by the boilers was practically dry under average running conditions, and was further dried in its passage to the cylinders; this was especially the case in the throttling tests. The percentage of moisture in the steam under average conditions was 1½%. Priming occurred in some of the boilers, due to the fact that the water was purified by chemical treatment; it was not possible to blow out the boilers frequently and the salts, when concentrated, caused foaming. The B. T. U. averaged 14,855 per lb. of coal, 11,992 per lb. of cinders, and 10,777 per lb. of sparks.

The results of the tests show the enormous power to which a locomotive boiler may be worked, the normal action of such boilers involving the delivery of approximately 12 lbs. of steam per ft. of fire heating surface per hour, and in one case as much as 16 lbs. Whereas in stationary practice it is customary to allow about 10 ft. of heating surface per boiler-HP., in these locomotives between 2 and 3 ft. only were required. The economy also was good in a number of tests, the equivalent evaporation per lb. of coal being 12 lbs., and in only a few cases as low as 6 lbs.

COMPARISON OF ENGINES.

The results of the tests show that the modern simple freight locomotive (of the types tested) can be depended upon to develop continuously from 1,000 to 1,100 HP., and the limit of power under constant conditions of running for the modern compound passenger locomotive may exceed 1,600 HP.

Particularly significant is the high economy which attends the action of the simple locomotive, over a wide range of action, for all speeds and cut-offs commonly employed upon the road, the variation in cylinder performance falling between the limits of 23.4 and 28.3 lbs. per I. HP.-hr. The compound locomotives tested when running under all speeds and cut-offs gave 1 I. HP. in return for the consumption of from 18.6 to 27 lbs. of steam. With the superheater locomotive (No. 7) the minimum consumption was reduced to 16.6 lbs. of superheated steam per hour. At all speeds the engines of the cross-compound locomotive (No. 3) were the most economical, although the advantage of the compound decreased with increase of speed. At the higher speeds the advantage of the compound in steam consumption is very small; in fact, there would be no difference at about 200 revolutions per minute. In general, the steam consumption of the simple engines decreased with increase of speed, while that of the compounds increased. This would lead to the conclusion that the steam distribution of the compounds was less satisfactory at high speeds than that of the simple locomotives.

In regard to water consumption, the following table shows a comparison of the averages for simple and compound engines:

	Freight Simple. lbs.	Freight Compound. lbs.	Passenger Compound. lbs.
Water per I. HP.-hr.:			
Minimum	23.67	20.26	18.86
With maximum load.	23.83	22.03	21.39
Maximum consumptn	28.95	25.31	24.41

Locomotive No. 8 was equipped with two reversing screws, so that the cut-off in the high and

SUMMARY OF RESULTS OF TESTS MADE ON THE PENNSYLVANIA R. R. LOCOMOTIVE TESTING PLANT, AT THE ST. LOUIS EXHIBITION, 1904.

	Freight Locomotives								Passenger Locomotives							
Locomotive.	No. 1		No. 2		No. 3		No. 4		No. 5		No. 6		No. 7.		No. 8.	
Railway	Pennsylvania		L. S. & M. S.		Mich. Cen.		A. T. & S. F.		A. T. & S. F.		N. Y. Cen.		Prussian State		Pennsylvania	
Type	2-8-0		2-8-0		2-8-0		2-10 2		4-4-2		4-4-2		4-4-2		4-4-2	
Builder	.....		.....		Am. Loco. Co.		Baldwin Lo. W'ks.		Baldwin Lo. W'ks.		Am. Loco. Co.		Germany		France	
Compounding	Simple		Simple		Two-cylinder		4-Cyl. tandem		Vauclain 4-Cyl. bal.		Cole 4-Cyl. bal.		4-cyl. bal.		De Glehn 4-cyl. bal.	
Cylinders, ins	(2) 22x28		(2) 21x30		(2) 23 & 35x32		(4) 19 & 32x32		15 & 25x26		15½ & 26x26		14⅛ & 22x23½		14⅛ & 23 11/16x25¼	
Driving wheels, ft.-ins	4-8		5-3		5-3		4-8½		5-7		6-7		6-2		6-8	
Boiler, volume, cu. ft	443.39		421.73		373.20		657.40		489.35		409.07		245.30		295.85	
Firebox, ft	9.6 x 5.5		10 x 3.3		7.6 x 5.5		8.8 x 6.3		9.8 x 5.5		8 x 6.25		4.6 x 6.25 wide		10 x 3.4	
Weight, total lbs	194,200		181,300		189,000		285,740		201,500		200,000		133,350		164,000	
Weight on drivers, lbs	172,200		162,600		164,500		233,760		99,200		110,000		65,350		87,850	
Tube heat. surface, sq. ft	2,677		2,639		3,015		4,601		3,017		3,255		1,512		1,469	
Total heat. " "	2,844		2,858		3,181		5,817		3,237		3,407		1,932		1,646	
Grate area, "	49.2		33.76		49.43		58.41		48.36		50		29.06		33.4	
Max. tractive effort, simple.	39,773		33,616		45,613		73.177		26,182		27.899		19,459		23,698	
" " compound	.....		.....		31.838		63,612		19,245		20.590		13,789		16,700	
Revolutions per min	92.74	160.84	80.46	160.05	80.18	159.97	40.00	81.28	160	280	160	320	160.06	280.27	160	280
Speed, miles per hr	15.40	26.72	15.09	30.00	15.01	29.96	6.72	13.65	37.59	65.77	37.52	75.05	37.15	65.05	38.26	66.96
Piston speed, ft. per min	432.6	750.2	402.2	800.1	428	854.1	213.58	434	693.6	1,213.6	692.6	1,385.3	630	1,103	672.7	1,176.1
Temperature in firebox (F).	1,662	1,940	2,000	2,312	1,060	1,620	1,507	1,932	1,835	2,177	2,180	2,174	2,118	2,043	1,872	2,044
" in smoke-box (F).	562	692	573	640	519	638	419	574	571	660	587	678	670	676	509	581
Rate of combustion, dry coal per hour:																
Per sq. ft. of grate area	42.40	.....	52.75	117.03	34.05	53.36	19.03	73.61	42.49	105.52	47.24	98.76	63.06	86.88	37.71	86.77
" " heat. surface	0.842	.....	0.701	1.554	0.597	0.936	0.258	0.998	0.708	1.759	0.786	1.642	1.045	1.44	0.474	1.09
Boiler pressure, lbs	197.6	172.1	200.3	201.6	205.8	175.1	215.4	213.5	220.6	219.5	222.2	222.3	202.6	204.2	219.6	215
Boiler, HP	596.50	823.90	488.8	819.7	526.7	793.3	374.7	1,067.0	612.4	1,085.8	696.8	1,129	484	577	400.3	679.8
Equivalent evap.:																
Lbs. water per lb. coal	9.85	7.32	9.47	7.16	10.80	7.66	11.63	8.56	10.28	7.34	10.20	7.91	9.11	7.89	10.97	8.10
Lbs. per sq. ft. grate surface, per hour	418	.....	500	838	368	554	221.3	630.2	436.9	774.7	481.7	781.0	574.5	685.2	413.6	702.4
Lbs. per sq. ft. heating surface, per hour	8.29	.....	6.64	11.13	6.45	9.71	3.00	8.55	7.28	12.91	8.01	12.99	9.52	11.36	5.20	8.83
Indicated HP	650.0	803.1	527.0	942.4	734.9	1,001.3	391.6	1,257.9	877.1	1,459.7	967.0	1,335 7	728.9	688.4	524.5	682.5
Dynamometer, HP	517.0	596.0	463.2	807.8	675.7	859.7	334.6	1,186.2	755.0	898.0	894.6	1,045.4	645.5	593.7	453.8	510.1
Frictional, H.P	133.0	207.1	63.8	134.6	59.2	141.6	57.0	119.7	122.1	561.7	72.4	290.3	83.4	94.7	70.7	172.4
Drawbar pull	12,587	8,366	11,515	10,096	16,879	10,762	18,680	31,240	7,533	5,120	8,940	5,224	6,516	3,422	4,448	2,857
Dry coal per I.HP. per hr.	3.13	4.77	3.28	4.12	2.23	3.82	2.73	3.37	2.28	3.45	2.34	3.64	2.38	3.53	2.31	4.10
Dry steam per I.HP. per hr.	25.51	29.19	25.89	24.67	20.15	24.43	26.47	24.04	19.44	20.78	19.60	23.51	16.60*	21.29	21.15	27.05
Efficiency of boiler	67.25	50.51	61.53	45.52	70.29	49.81	74.31	54.69	66.16	47.27	65.38	51.02	58.28	50.73	70.68	51.48
Efficiency of locomotive	4.57	2.82	4.59	3.49	7.08	3.86	5.27	4.51	6.40	3.03	6.67	3.42	6.27	4.14	6.35	3.06

* superheated steam.

low-pressure cylinders could be varied independently, the average difference being 24½%. No. 7 had a constant difference of cut-off in the high and low pressure cylinders of about 17% (designed to be 20%), while Nos. 5 and 6 had the same cut-off in both cylinders.

COMPARISON OF LOCOMOTIVES.

The tests of the boilers and of the engines, considered separately, have been given above. Taking the locomotive as a whole (boiler and engine as one unit), the records of steam consumption per I. HP.-hr., as well as of steam and coal per dynamometer HP.-hour, are stated to indicate that the performance of the steam locomotive is far better than is commonly supposed, and that the economy compares favorably with that of other methods of traction. At 160 revolutions per minute, the economy of all the locomotives was almost the same, but Nos. 5 and 6 developed higher power than the others, while No. 5 showed less variation in steam consumption for different HP. than any of the other locomotives. At a speed of 240 revolutions the sharp increase of steam consumption for No. 7 indicated that it was working at the limit of its capacity, while the decrease in consumption for No. 8 at this speed apparently showed that it had not reached the full capacity of the engines, although the boiler was worked until it failed to furnish sufficient steam.

All of the tests indicate the desirability of using locomotives with ample margin of power for the average work to be done, and no disadvantage is shown by these tests in operating locomotives at considerably less than their maximum capacity. In fact, a reduction in HP. is accompanied by a substantial gain in economy. For example, passenger locomotives Nos. 5 and 6 show a maximum capacity in dynamometer HP. of 1,300 HP. and 1,475 HP.; these engines will be run in actual service with trains requiring a probable average of 1,000 dynamometer HP., or less. From the tests it is seen that both locomotives were considerably more economical at the lower HP. than at the higher HP., while the capacity for the greater HP. is always available for emergencies. The figures for the remaining engines, both freight and passenger, show the same characteristics of increased economy with average instead of maximum loads, thus showing that the locomotive is a very flexible machine in its adaptability to railway requirements.

LUBRICATION.

Tests were made as to the friction losses with oil and with grease lubrication for rods and axles, but it was found that the friction loss at the driving axle journal was so large a factor in the total friction as to obscure the effect of rod lubrication, whether grease or oil. It appears from the plotted results that the use of grease may be expected to increase the friction losses per axle by from 75 to over 100%.

COUNTERBALANCING.

The investigation of the effects of counterbalancing in the passenger engines was made by observing the following: 1, Critical speed; 2, Nosing or vibration at the pilot; 3, Variation of the driving wheel pressures upon the supporting wheels of the testing machine. The critical speed is the lowest speed at which the disturbing forces in the locomotive first affected the dynamometer, varying from 96 to 176 revolutions per minute in the freight engines, and from 180 to 320 revolutions in the passenger engines. The curves obtained from No. 6 show the smallest vibration. The counterbalance weights of No. 5 were directly in line with the crank, while those of the other three engines were angularly displaced. This refinement was responsible for the small vibrations of Nos. 6, 7 and 8. It is stated, however, that the tests showed that a four-cylinder locomotive can be perfectly balanced by distributing rotating counterweights between the two wheels in such a manner that the moments of all rotating weights shall balance each other in every plane.

In the tests of variation of driving wheel pressures, made by running wires between the driving and supporting wheels, it appears that in Nos. 7 and 8 the driving wheels vibrated upon the supporting wheels, this being indicated by the rapid changes in the thickness of the wires for these engines. It is to be noted that these were the highest passenger engines tested, which may account for the vibration. The variations in the thickness of wires for the other engines were more regular, but were greater in No. 5, and in one case the driving wheel of this engine lifted from the supporting wheel. The report states that the correct counterbalancing of a four-cylinder balanced compound locomotive can be satisfactorily accomplished.

We reprint in full the summary of conclusions which accompanies the report:

BOILER PERFORMANCE.

1. Contrary to a common assumption, the results show that when forced to maximum power, the large boilers delivered as much steam per unit area of heating surface as the small ones.

2. At maximum power, a majority of the boilers tested, delivered 12 lbs. (or more) of steam per sq. ft. of heating surface per hour; two delivered more than 14 lbs., and one, the second in point of size, delivered 16.3 lbs. These values expressed in terms of boiler HP. per sq. ft. of heating surface are 0.34, 0.40 and 0.47, respectively.

3. The two boilers holding the first and second place with respect to weight of steam delivered per sq. ft. of heating surface, are those of passenger locomotives.

4. The quality of steam delivered by the boilers of locomotives under constant conditions of operation is high, varying somewhat with different locomotives and with changes in the amount of power developed, between the limits of 98.3% and 99.0%.

5. The evaporative efficiency is generally maximum when the power delivered is least. Under conditions of maximum efficiency, most of the boilers tested evaporated between 10 and 12 lbs. of water per lb. of dry coal. The efficiency falls as the rate of evaporation increases. When the power developed is greatest, its value commonly lies between limits of 6 and 8 lbs. of water per lb. of dry coal.

6. The observed temperature of the firebox under low rates of combustion lies between the limits of 1,400° F. and 2,000° F., depending apparently upon characteristics of the locomotive. As the rate of combustion is increased, the temperature slowly increases, maximum values generally lying between the limits of 2,100° and 2,300° F.

7. The smokebox temperature for all boilers, when worked at light power, is not far from 500° F. As the power is increased, the temperature rises, the maximum value depending upon the extent to which the boiler is forced. For the locomotives tested, it lies in most cases between 600 and 700°.

8. With reference to grate area, the results prove beyond question that the furnace losses due to excess air are not increased by increasing the area. In general, it appears that the boilers for which the ratio of grate surface to heating surface is largest are those of greatest capacity.

9. A brick arch in the firebox results in some increase in furnace temperature and improves the combustion of the gases.

10. The loss of heat through imperfect combustion is in most cases small, except as represented by the discharge from the stack of solid particles of fuel.

11. Relatively large firebox heating surface appears to give no advantage either with reference to capacity or efficiency. The fact seems to be that the tube heating surface is capable of absorbing such heat as may not be taken up by the firebox.

12. The value of the Serve tube over the plain tube of the same outside diameter, either as a means for increasing capacity or efficiency, was not definitely determined.

13. The draft in the front-end for any given rate of combustion as measured in inches of water, depends upon the proportions of the locomotive and the thickness and condition of the fire. Under light power, its value may not exceed an inch, but it increases rapidly as the power is increased. Representative maximum values derived from the tests lie between the limits of 5 ins. and 8.8 ins.

14. Insufficient openings in the ash-pan and the mechanism of the front end, especially the diaphragm, are shown by the tests to lead to the dissipation of considerable portions of the draft force.

THE ENGINE.

15. The Ind. HP. of the modern simple freight locomotive tested may be as great as 1,000 or 1,100; that of a modern compound passenger locomotive may exceed 1,600 HP.

16. The maximum Ind. HP. per sq. ft. of grate surface lies, for the freight locomotives, between the limits of 31.2 and 21.1 HP; for the passenger locomotives, between the limits of 33.5 and 28.1 HP.

17. The steam consumption per Ind. HP. necessarily depends upon the conditions of speed and cut-off. For the simple freight locomotives tested the average minimum is 23.7. The consumption when developing maximum power is 23.8 and when under those conditions which proved to be the least efficient, 29.0.

18. The compound locomotives tested, using saturated steam, consumed from 18.6 to 27 lbs. of steam per Ind. HP. hour. Aided by a superheater, the minimum consumption is reduced to 16.6 lbs. of superheated steam per hour.

19. In general, the steam consumption of locomotives decreases with increase of speed, while that of the compound locomotives increases. From this statement it appears that the relative advantage to be derived from the use of the compound diminishes as the speed is increased.

20. Tests under a partially opened throttle show that when the degree of throttling is slight the loss is not

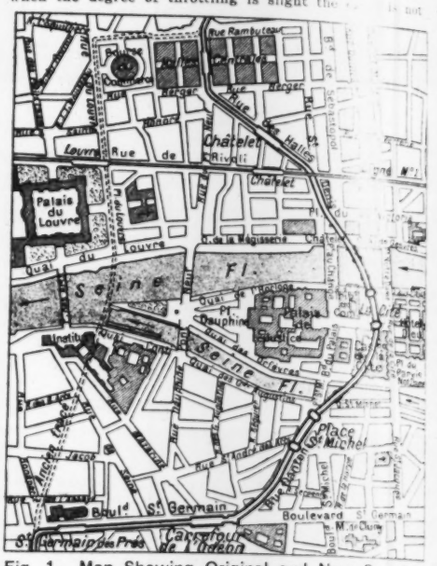


Fig. 1. Map Showing Original and New Crossing of the River Seine by the Metropolitan Railway of Paris.

appreciable. When the degree of throttling is more pronounced, the performance is less satisfactory than when carrying the same load with a full throttle and a shorter cut-off.

THE LOCOMOTIVE AS A WHOLE.

21. The percentage of the cylinder power which appears as a stress in the drawbar, diminishes with increase of speed. At 40 revolutions per minute, the maximum is 94 and the minimum 77; at 280 revolutions per minute, the maximum is 87 and the minimum 62.

22. The loss of power between the cylinder and drawbar is greatly affected by the character of the lubricant. It appears from the tests that the substitution of grease for oil upon axles and crank pins increases the machine friction from 75 to 100%.

23. The coal consumption per dynamometer HP.-hour for the simple freight locomotives tested, is at low speeds not less than 3.5 lbs. nor more than 4.5 lbs., the value varying with running conditions. At the highest speeds covered by the tests, the coal consumption for the simple locomotives increased to more than 5 lbs.

24. The coal consumption per dynamometer HP.-hour for the compound freight locomotives tested is, for low speeds, between 2.0 and 3.7 lbs. Results at higher speeds were obtained only from a two-cylinder compound, the efficiency of which under all conditions is shown to be very high. The coal consumption per dynamometer HP.-hour for this locomotive at the higher speeds increases from 3.2 to 3.6 lbs.

25. The coal consumption per dynamometer HP.-hour, for the four compound passenger locomotives tested,

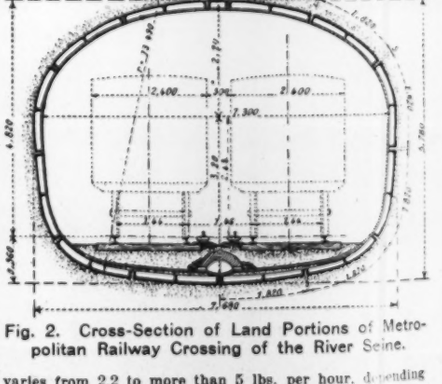


Fig. 2. Cross-Section of Land Portions of Metropolitan Railway Crossing of the River Seine.

varies from 2.2 to more than 5 lbs. per hour, depending upon the running conditions. In the case of all of these locomotives, the consumption increases rapidly as the speed is increased.

26. A comparison of the performance of the compound freight locomotives with that of the simple freight loco-

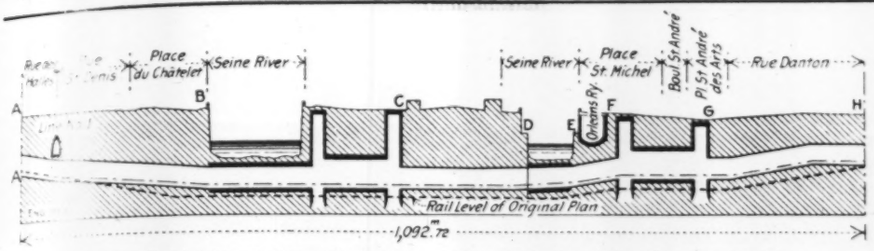


FIG. 3. PROFILE OF METROPOLITAN RAILWAY CROSSING OF RIVER SEINE.

motives is very favorable to the compounds. For a given amount of power at the drawbar, the poorest compound shows a saving in coal over the best simple which will average above 10%, while the best compound shows a saving over the poorest simple which is not far from 40%. It should be remembered, however, that the conditions of the tests, which provide for the continuous operation of the locomotives at constant speed and load throughout the period covered by the observations, are all favorable to the compound.

27. It is a fact of more than ordinary significance that a steam locomotive is capable of delivering a horse-power at the drawbar upon the consumption of but a trifle more than 2 lbs. of coal per hour. This fact gives the locomotive high rank as a steam power plant.

28. It is worthy of mention that the coal consumption per HP.-hour developed at the drawbar by the different locomotives tested presents marked differences. Some of these are easily explained from a consideration of the characteristics of the locomotives involved. Where the data are not sufficient to permit the assignment of a definite cause, there can be no doubt but that an extension of the study already made will serve to reveal it.

THE REMARKABLE TUNNEL CROSSING OF THE SEINE BY LINE 4, METROPOLITAN RAILWAY OF PARIS.

Sections of complete tunnel constructed as caissons and sunk end to end to grade will form the tunnel crossing the Seine by the north and south transverse line (Line No. 4) of the Metropolitan Railway of Paris. This line runs from the Porte de Clignancourt to the Porte d'Orleans, and was originally planned to cross the river above the Pont des Arts and just where the famous stream separates around the Ile de la Cite; opposition to the passage of the underground road under the Palais de l'Institute led to a change in location. The line was swung east in a loop to a crossing between the Pont Notre Dame and the Pont au Change, over the main branch of the Seine and just up-stream from the Pont St. Michel over the small branch of the Seine. The locations of the original and the new lines are shown by the map Fig. 1.

GENERAL PLAN.—The choice of a plan for the river crossing was placed in the hands of a commission, which selected from a number the plan proposed by Mr. L. Chagnaud, a well-known Paris contractor. It had been previously proposed to make the crossing with twin-tube tunnels lined with iron and built with shields and compressed air. Mr. Chagnaud proposed a single-tube double-track tunnel of the section shown by Fig. 2, iron-lined and driven by shield in the main land portions and constructed with caissons and by freezing in the other portions.

The profile Fig. 3 shows the general plan of the work. The sections A B, C D and G H comprise the shield work; sections of complete tunnel built as caissons and sunk from the surface were planned for sections B C, D E and F G, comprising the under-river portions and the stations La Cité and Place St. Michel, and the freezing process was planned for the short section E F. It will be noted from the profile that the adopted plan resulted in a considerable reduction of grades. This, coupled with the fact that it called for no change from the normal cross-sectional profile of the other parts of the line, was the principal inducement to the selection of the Chagnaud plan.

The total length of line comprised in the special crossing plan is 1,092.72 m. (3,584 ft.), of which 621.45 m. are shield work, 402.2 m. are caisson work and 62.27 m. work by the freezing process. For the present the 1,313 ft. of caisson work alone will be considered, full information not being yet available regarding the shield and the freezing work. It may be noted in respect to Fig. 2, however, that the sectional profile to be cut out by the shield and lined with cast iron is practically the same as that of the regular masonry-lined section. The same cross-section and lining construction will be maintained through the short length built by the freezing process. This length, it will be noted from Fig. 3, carries the road under the tunnel of the Orleans Railway.

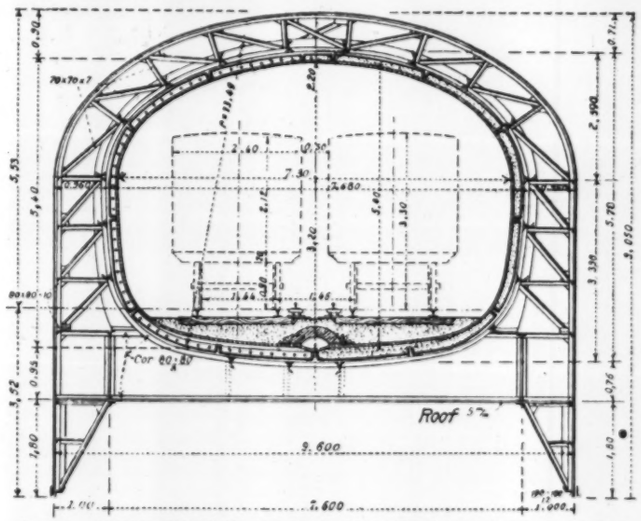


FIG. 4. CROSS-SECTION OF CAISSONS FORMING RIVER TUNNELS.

CAISSON CONSTRUCTION.

Turning now to the caisson work, which is the special subject of this description, it may be summarized by saying that three caissons will be sunk end to end to form the crossing of the main stream, and two others, similarly arranged, to form the crossing of the smaller branch; while three caissons will be sunk to form each of the two stations.

RIVER CAISSONS.—The caissons for the river crossings may be roughly described as lengths of tunnel lining enveloped by a framework of metal embedded in concrete. The idea is clearly conveyed by Fig. 4. Frames of the form shown by the drawing hoop the lining every 1.2 m. (3.94 ft.) and carry a shell of steel plating on the sides from toes to springing lines and on the sides and roof of the working chamber. A temporary plate diaphragm closes the open ends. The construction forms a vessel capable of floating with very light draft. The only difference in the construction of the five river caissons are the different lengths to which they are built; the three caissons for the main crossing are 36 m., 38.4 m. and 43.2 m. (118, 125.9 and 141.7 ft.) long, and the two caissons for the smaller crossing are each 19.8 m. (65.9 ft.) long.

STATION CAISSONS.—Two forms of caissons are employed in the station work, and, as the two stations are identical in dimensions, only one caisson of each form need be described. Each station is composed of three caissons, a center caisson forming the station proper and two end caissons connecting the enlarged station cross-section with the normal tunnel cross-section and forming the passages of communication between the surface and the underground station platforms. The center caisson has the cross-section shown in Fig. 5 and is 68 m. (223 ft.) long. Its construction is substantially the same as that of the caissons for the river crossings. The end caissons are elliptical cylinders, set with their major axes at right angles to the line of the tunnel; these cylinders have diameters of 18.5 m. and 26 m. (60.68 ft. and 85.3 ft.). They consist of an inner and an outer shell, braced apart by a steel framework and filled between with concrete.

METHOD OF SINKING CAISSONS.

Only one caisson, and this one of those for the main stream crossing, has so far been sunk to position. It is planned, however, to handle all the river caissons by the same methods, so that a description of the work for one will serve to

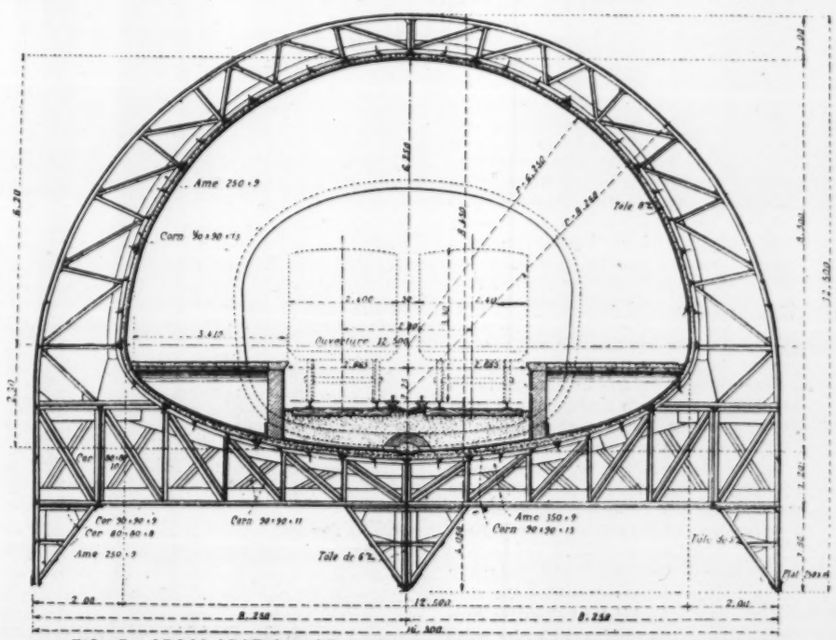


FIG. 5. CROSS-SECTION OF MAIN CAISSON FORMING TUNNEL STATIONS.

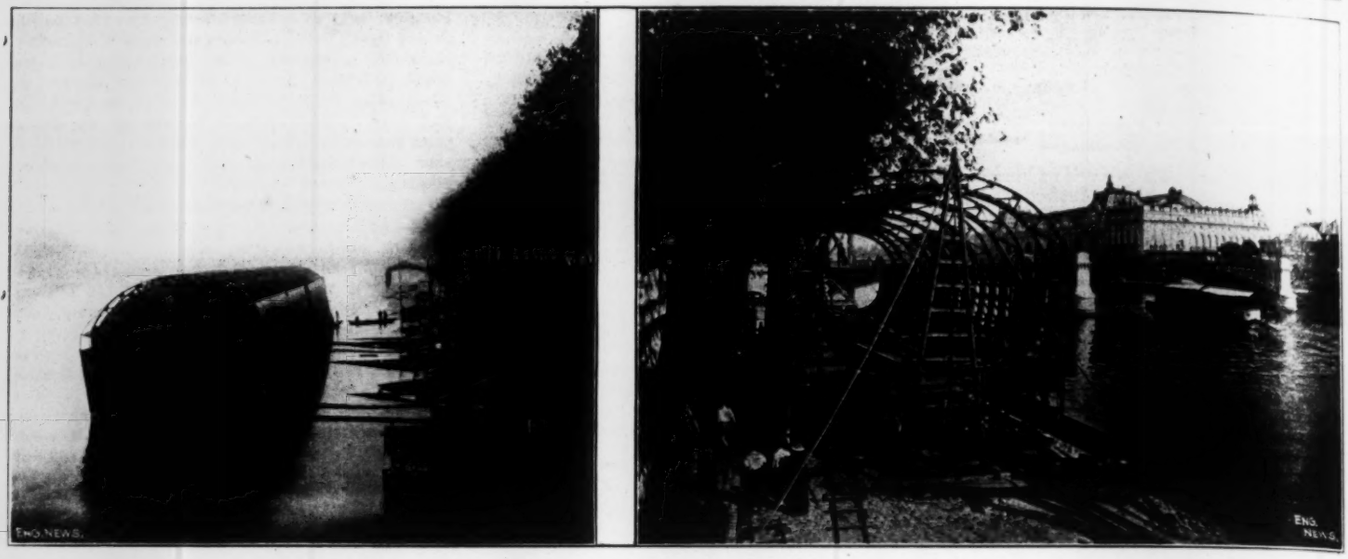


FIG. 6. VIEWS SHOWING CAISSON ON WAYS AND AFTER LAUNCHING.

indicate the probable procedure with the others. The caisson already sunk is the 36 m. (118 ft.) caisson for the main river crossing. The first work was the erection of the caisson on ways on the river bank, as shown by Fig. 6. After erection the caisson was launched and towed into position between pile stagings, which served the double purpose of guiding the descent at the beginning of sinking and of forming a working platform. The character and arrangement of the staging are shown by the diagram Fig. 7. The caisson, when launched, and, consequently, before the cast-iron lining had been put in place within it, weighed 280 metric tons, but beyond some difficulty in taking it under the bridges in the way the towing was accomplished without serious trouble.

Previous to placing the caisson in position between the stagings the portion of the river bed it was to rest upon had been leveled by dredging. Once in position, the first work was the erecting of the cast-iron lining segments within the framework. Work was then begun filling the annular space between lining and shell with concrete, this addition of weight gradually sinking the caisson to the river bottom. As the sinking progressed up to this point the working shafts (steel cylinders) indicated in Fig. 7 were placed. Referring to Fig. 8, the floating position of the caisson is shown at A, and its position on the river bottom with the concrete filling complete is shown at B. The next step was to apply air pressure and lay dry the working chamber, as shown at C. Sketches D, E and F show succeeding stages of the work to completion. No special difficulty was experienced in sinking the caisson, aside from the hardness of the material, which had to be broken up by blasts. The progress was from 20 to 30 cm. (8 to 12 ins.) per day.

One of the features of the work which naturally arouses inquiry is the manner in which the several caissons will be connected up to form a continuous tunnel. It is planned to sink the caissons so that a space of 1.5 m. (4.92 ft.) is left between adjacent ends, and to close this space by building in an equal section of lining and envelope. The actual method of accomplishing the work is not announced further than to state that the construction will be carried on inside of special movable caissons.

In conclusion, it should be stated that we are indebted to "Le Genie Civil" of Dec. 2, 1905, for the information from which this account of the Seine tunnels has been prepared.

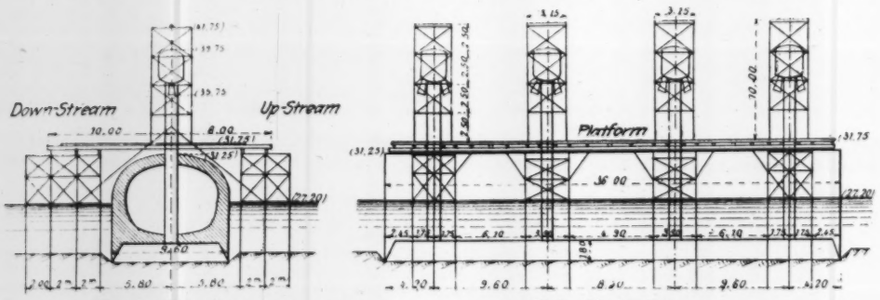


FIG. 7. DIAGRAM SHOWING CAISSON AND WORKING STAGINGS.

HYDROGRAPHIC WORK OF THE U. S. GEOLOGICAL SURVEY IN NEW ENGLAND.

The hydrographic work now being done by the U. S. Geological Survey in New England includes measurements of stream flow, surveys of important streams and the preparation of plans and profiles thereof, surveys of lakes and ponds to determine the possibility of water storage, and the compilation of data in connection with the work and objects outlined.

There are 41 public river gaging stations in New England, divided as follows: Maine, 20; New Hampshire, 12; Vermont, 2; Massachusetts, 6; Rhode Island, 1; Connecticut, 2. In addition reliable figures of stream flow are obtained from some fifteen private stations in the states named.

The chief demand for information based on this hydrographic work is along the following lines: Maine, water power and the regulation of storage therefor; New Hampshire, the effect of deforestation on the run-off of the White Mountain region; lower New England, public water supply and sewage disposal, with an increasing interest in water power.

As to increasing water storage in the many lakes of Maine, and thus regulating the flow of the associated streams, the Survey announces that by the end of another season it hopes to be able to outline a comprehensive scheme for improving storage on the Kennebec. Careful records of evaporation from lake and river surfaces are now being kept.

The New England office of the hydrographic division of the U. S. Geological Survey is at Boston. Here five men are at work. During the past year two field parties were out, five men surveying the Androscoggin River, and nine men surveying the headwaters of the Kennebec and Penobscot rivers, for information on storage improvement possibilities.

SPRINKLING OR PERCOLATING SEWAGE FILTERS were proposed in nine-tenths of the schemes that came before the British Local Government Board for approval in 1905, according to the London "Public Health Engineer." From the same source we learn that peppermint has proved a successful crop on land receiving sewage at Sutton (Surrey), England. The first crop was raised in 1904, on six acres of land, and "yielded," whatever that may mean, £13, or about $63. The 1905 crop "sold for no less than £145," or about $700.

A 700-FT STEEL TOWER is projected as an amusement feature at Coney Island, New York City. The tower will be 300 ft. square at the base and will support a huge open globe, 300 ft. in diameter at a point about 350 ft. above the ground. It is estimated that the structure would require over 7,000 tons of steel work and would cost over $1,000,000. The originator and designer of the tower is Mr. Samuel M. Friede, and a company has been organized to raise funds and build the structure, with offices at 27 William St., New York City.

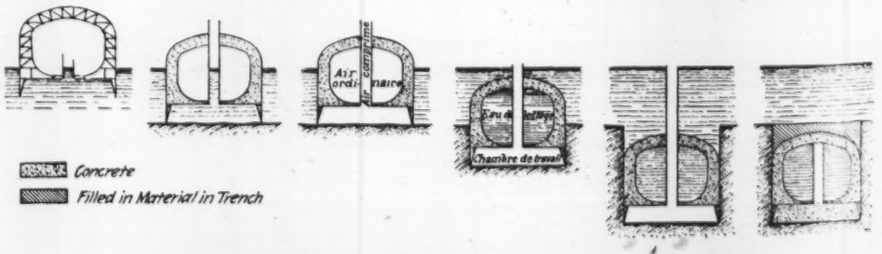


FIG. 8. DIAGRAM SHOWING SUCCESSIVE STEPS IN SINKING CAISSON.

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The Report of the Board of Consulting Engineers for the Panama Canal is announced on the bulletin on the front cover of this issue, and was expected to be released for publication when that part of the issue went to press. Delay in the official publication of the Report, however, makes it necessary for us to postpone it to a following issue.

A plan is now before the public to place all the passenger transportation lines of Manhattan and Bronx Boroughs in New York City, surface, underground and elevated, in control of a new "holding corporation," which is to have a capitalization of $205,000,000, divided between common stock, preferred stock and bonds. The various companies which it is proposed to control and operate in combination have themselves been formed through such a complicated labyrinth of leases, consolidations, reorganizations and all the other devices of up-to-date high finance that the puzzle as to what the different stockholders really own is in some cases too much for even an expert accountant to unravel.

The various companies which are to be virtually consolidated under this plan have in the course of their past history, and particularly their recent history, issued stocks and bonds in watery profusion, a large part of which still remain outstanding. Without attempting to unravel the whole snare, it appears from a statement in the "Journal of Commerce" that the railway lines of this consolidated system, if the merger is effected, will have the following bonds and stocks outstanding against them:

Security (?)	Amount.	Annual charge for interest or dividends.
Bonds of merged companies....	$164,765,000	$8,238,000*
Manhattan Ry. Stock (7%).....	55,200,000	3,864,000
Bonds of holding Co. (4½%).....	70,000,000	3,150,000
P'f'd stock of holding Co. (5%).	52,000,000	2,600,000
Common stock of holding Co...	83,000,000	?
Total	$424,965,000	$17,842,000

*Estimated at 5%.

This proposed consolidation has received the unanimous condemnation of the press of New York City as subversive of both the rights of the public and of a large part of the stockholders, and contrary to sound public policy.

We have called attention to it here because it illustrates what we hold to be the chief evil of the present day in connection with the control of enterprise by vast corporations. That evil is in brief the use of corporations—and particularly municipal franchise corporations—to roll up wealth for those which control them by a process which, although it may be within the letter of the law, is in its aim and result fraudulent.

What honest or legitimate object, let us ask, was ever served by the series of transformations by which the Metropolitan Street Ry. Co. was leased to the New York City Ry. Co., this in turn to the Metropolitan Securities Co., and now this in turn to the proposed new holding company? Did the interests of the stockholders require these various feats of financial legerdermain on the part of those in control of the corporation, or was the impelling motive the glittering opportunity to get rich quickly which such periods of cataclysm in corporation affairs always afford to those who are on the inside?

The greatest influence to-day working for municipal ownership of public utilities is the fact that our great street railway and lighting plants are controlled not on a business basis, but on a basis of speculative gambling. The get-rich-quick idea is everywhere prevalent. There is no longer any attraction to our high financiers in building up a business, making legitimate profits, giving good public service and creating works of permanence. Instead, the permanent welfare of the property and of its business is a trifling matter. The directors are chiefly concerned in effecting some deal or lease or consolidation by which the market prices of stocks and bonds will suddenly rise or fall. Working in co-operation with the bankers and lawyers whose business it is to carry out these consolidations and reorganizations, money can be made so rapidly that only an old fogy will go on year after year in the prosaic business of earning and paying dividends to stockholders. The modern plan is to pay just enough to the stockholders to induce them to bite the second time; and eventually so to tangle the corporation's affairs that the stockholder cannot tell what his shares represent. He can then the more easily be induced to part with them, or to keep them, whichever may suit the interest of the controlling spirits.

If municipal ownership is compared with this actual condition of affairs and not with the ideally efficient privately-managed business, with which we are accustomed to hear it compared, an exceedingly strong case can be made out in its favor.

A PROPOSED REVISION OF THE NEW YORK BUILDING CODE.

For some time past there has existed an active sentiment for the revision of the present municipal building laws of New York City. It has come to be recognized that the much-quoted New York Building Code is no longer adequate to meet the city's needs. Its defects, constantly increasing as the art progressed while the law stood still, have been felt severely, alike by architects and contractors, engineers and munipical building authorities. Several months ago the Mayor, in a message to the Board of Aldermen, strongly urged that he be authorized to appoint a commission to draw up a revised building code. The Board of Aldermen preferred another mode of accomplishing the revision, and a week or two ago it adopted the following resolution:

> Resolved, That, in pursuance of Section 407 of the Greater New York Charter, the Building Committee of this Board be, and it hereby is, directed to prepare and report to this Board a "Building Code," in amended and revised form, providing therein for all matters concerning, affecting or relating to the construction, alteration and removal of buildings or structures erected, or to be erected, in the City of New York; and it is further
>
> Resolved, That for the purpose of properly preparing said Building Code the said committee be, and it hereby is, authorized to engage the services of the following experts, each of whom shall be a resident of the City of New York, and shall have been engaged not less than five years in his respective calling, to wit: A builder, an ironworker, a mason, a carpenter, a plumber, an architect, a civil engineer, a sanitary engineer, a physician and a lawyer, which said experts shall be paid a reasonable compensation for the services to be rendered by them, the compensation to be fixed by this Board after the service has been completed.

This resolution is now in force. No steps have yet been taken, so far as we know, toward the formation of the commission of ten experts described, but presumably this will soon be done.

The proposed work is of enormous importance. The influential position of the New York Building Code, both in the City of New York where it absolutely controls all building operations and elsewhere in the country where it is esteemed as a weighty precedent, is alone sufficient to lend wide interest to any prospective revision. Of even greater moment is the nature of the conditions which call for a revision. The present Code, outside of the restrictive and permissive or "law" clauses, is essentially an engineering specification, which defines in great detail how to design and build. It was drawn up seven years ago. During its life it has been found inadequate in some respects and has become out-of-date in others. If it were brought up to date now, it would probably in seven years again exhibit many defects; the wear of time affects all specifications. Largely on this account, in the last few years very serious thought has been given to the question of whether a building law should be a detailed specification or whether it should be a general law, defining purposes and giving power to proper officials to prescribe detail regulations, to be revised from time to time, by orderly procedure. The latter view is backed by effective argument and influential adherents. The revisers of the Code ought therefore, first of all, before any work on a new Code is undertaken, decide whether the new Code shall be formed on the plan of the old or shall include only more general requirements as above outlined.

Again, a bomb was thrown into the camp of municipal building practice by the Baltimore conflagration, two years ago. The Fire Underwriters, impressed with the teachings of Baltimore, have since then made comprehensive "conflagration hazard" studies of our important cities and have prepared maps exhibiting their condition. The "conflagration map" of New York City is far from reassuring, and those familiar with the present Building Code know that its provisions are not at all effective in reducing the conflagration hazard. The Code prepared to-day will have much influence on the liability of the city to suffer from a great fire, 20 to 50 years hence.

Perhaps as important as any question which affects the New York Code situation at present is: how shall the responsibility for proper design and construction be apportioned and enforced? This question is of unusual breadth. To even sketch its main bearings and arguments in this place would lead far away from our theme. Suffice it to say that at present the division of responsibility is but an uncertain resultant of common-law principles. In consequence, responsibility is shouldered about from owner to architect to contractor to city inspector, with but one outcome—shoddy work. There has frequently been a pressure toward concentrating the responsibility on the municipal building supervision. Quite aside from its manifect impropriety from the technical standpoint, such imposition of responsibility would prove illusory because wholly impracticable from the administrative standpoint: the city is physically and financially unable to design and supervise building work for its citizens. Now, some very simple proposals have been made for settling the responsibility in a definite way, namely, (1) to license architects and require them to supervise their work; (2) to license builders and hold them responsible for everything but design, leaving that upon the architect or engineer under common-law principles; (3) to require each job to have either an approved (registered) architect or an approved (registered) builder, or both; (4) to require each job to have either a registered architect, or a registered builder, or a registered superintendent. [The latter two proposals evidently avoid the "close profession" evils, and the fourth has the added merit of creating a valuable professional grade, Building Superintendent or Manager.] The consideration of these and similar proposals, if taken up at all, would necessarily be an early and fundamental part of the revision, and under the present conditions in New York it is essential that such consideration be entered into in any adequate revision of the Building Code.

These and many other broad problems, all of great complexity and gravity, will form the main

part of the work which lies before the Code Revisors. We lay less stress on the working out of details of the specification (if the specification plan be adopted), for the reason that any defective provision will be localized in its effect to one detail or one branch of building work, while the broad primary questions affect all work and the entire city. It may be (though we trust not) that these primary problems will be neglected or even ignored in the actual revision, and chief attention be given the specification details; but the former will still remain the principal part of what the revisors *should* do.

As seen from the resolution above, the revision is to be made by a board of ten men, half of whom are to be workmen in the building trades, two others are, respectively, a physician and a lawyer, and three only are to be professional experts, competent (if properly selected) for the responsible task of Code revision.

Can the City of New York afford to entrust the vast interests of public safety and the security of private investments that are affected by its Building Code to a board so constituted? In what way does work at the mason's trade, or the plumber's trade, or the carpenter's trade, render a man competent to pass on such a weighty question as the division of responsibility for safe building construction between the owner and the City Building Department; or such an intricate problem as the reasonable requirements for fireproof construction under the new conditions of high-priced lumber and low-priced cement and concrete? Let us go a step farther, even, and ask what the vast building and real estate interests of New York City have to say to the proposition of having, very possibly, a member of the Mason's Union placed on a board which will be able to greatly hamper and restrict the use of concrete in building construction?

We do not question the good faith or good intentions of the Board of Aldermen in this matter. The resolution bears evidence on its face that it was planned with the idea of giving representation to all the special interests which the drafter of the resolution supposed to be concerned in or affected by the revision. But it is just here that the mistake lies. The workmen at the carpenter's trade or the plumber's trade have little or no direct interest in how the Building Code may be revised; and are not even competent by their trade experience to figure as experts in the work of Building Code revision. As well might one place the fireman who shovels coal into a boiler furnace upon a commission to revise the laws and ordinances for municipal inspection of steam boilers.

The fact is that the work of Building Code Revision demands technical experts of the highest order and of judicial qualifications. Men with professional honor are needed who can be trusted to follow a straight course, no matter what the inducements offered or the pressure brought to bear by special interests. Such men, who have devoted years of study to and are thoroughly familiar with these problems, can be found among the architects and engineers engaged in building construction, among the fire protection engineers and in the city's own Building Department and Tenement House Department.

A year ago, when the city of Baltimore was in need of a new building ordinance that should render impossible a repetition of the great conflagration that destroyed its business district, it employed an engineer of the highest standing and long experience in building construction to draft its new code. The same plan has been followed we believe in other cities.

In the case of New York, the task is great enough and important enough to demand the labor of three to five of the best experts that can anywhere be procured. We urge that the Board of Aldermen reconsider the resolution and give attention to the matters we have above presented. We believe that if the subject be looked at from the standpoint of the public interest alone, which is the sole interest we have in view, it will be entirely possible to secure such reconsideration and the creation of a commission which will be competent to make a Building Code for New York City that will serve as a model for American cities.

LOCOMOTIVE TESTING PLANTS AND THE ST. LOUIS TESTS.

The results of international exhibitions are usually very indefinite and intangible, being mainly of an advertising and vaguely educational character, and this is particularly true of the engineering and technical departments. The St. Louis exhibition of 1904, however, is notable for the definite and valuable results obtained in certain lines of scientific investigation, including especially the tests of locomotives by the Pennsylvania R. R. and the fuel tests of the U. S. Geological Survey.

The locomotive testing plant installed by the Pennsylvania R. R. at St. Louis was designed for eventual installation at the company's extensive shops at Altoona, to be used in the study of locomotive design. It is adaptable to any type of locomotive for passenger or freight service, and it is capable of absorbing for a prolonged period the maximum power of a modern locomotive when running at any rate of speed between 10 and 75 miles per hour. In connection with this was a specially designed traction dynamometer of sufficient capacity to register the tractive power of the most powerful locomotives, and at the same time so sensitive as to indicate slight variations in the force exerted. This dynamometer can measure a maximum draw-bar pull of 80,000 lbs.

It was originally intended to install the plant merely as an exhibit at St. Louis, but this plan developed into a comprehensive scheme for carrying on a series of tests of locomotives of different types at the exhibition, which involved much additional equipment and a large outfit of instruments and apparatus. Steps were also taken to enlist the interest of scientific bodies, railway companies and locomotive builders, in order that the work might be conducted on a broad scientific and practical basis, and not as the private work of a single company.

The Pennsylvania R. R. Co. had a vice-president and three of the leading officers of its motive power department in charge of the work, and it was decided that the tests should be planned and conducted in conjunction with an "advisory committee," composed of mechanical engineers representing scientific investigation, railway mechanical departments and the locomotive building interests. The active co-operation of the American Society of Mechanical Engineers and the American Railway Master Mechanics' Association was secured, and each of these institutions appointed three members of the committee, all men of high professional standing. These, with a representative of a locomotive building firm not represented by any of the first six members, with two foreign railway engineers (one English and the other German), and with a representative of the Transportation Department of the exhibition, constituted the advisory committee. A complete corps of engineers, observers and computers was organized to carry out the tests; to record, tabulate and analyze the results; and to prepare these results for publication in the interests of locomotive engineering in particular and the engineering profession in general. The financial expenditures were very large, not only in the installation, but also in the operation of the plant; and the Pennsylvania R. R. Co. deserves great credit for the liberality with which money was furnished for the purpose of making the tests as complete and valuable as possible.

Of the design of the testing plant it is not necessary to speak here, as it has already been fully described in our columns. As probably all of our readers know, the engine is anchored or coupled to a dynamometer, and its driving wheels rest upon carrying wheels which are revolved by the action of the driving wheels; upon the axles of these carrying wheels are hydraulic disk brakes, and the work done by the locomotive consists in overcoming the frictional resistance of the carrying wheels and their brakes, the resulting force exerted at the draw-bar being measured by the traction dynamometer through which the locomotive is anchored.

The idea of making tests with a locomotive having its wheels free from the rails and its work absorbed by external means is believed to have originated with Alexander Borodin, Engineer of the Southwestern Ry, of Russ[illegible] who in 1881-82 made a number of shop tests [illegible] locomotives running with their wheels b[illegible]ed up clear of the rails and having their p[illegible]r absorbed by the shop machinery. In 1[illegible] when establishing an engineering laboratory [illegible]rdue University, Prof. W. F. M. Goss conc[illegible]d the idea of running a locomotive held stati[illegible]y and carried on supporting wheels in a l[illegible]tory, where the operating conditions could [illegible] kept constant and uniform without the inte[illegible]tions and variations which enter into road t[illegible]. At the time he had no knowledge of the earlier Russian experiments, and learned of th[illegible] only when Mr. Borodin visited the Purdue plan[illegible] about two years later. This plant was desig[illegible]d and the first locomotive installed in 1891 at the university, where varied and extensive investigations of great practical and scientific valu[illegible] have since been made.

There are naturally very few such plants in existence, owing to their high cost. In this country there are four—two owned by Purdue and Columbia universities, and the others by the Pennsylvania R. R. and the Chicago & Northwestern Ry. There is one in Russia, and one of the latest is that installed by the Great Western Ry., of England, at its works at Swindon. This last plant is intended not only for investigation work, but also to largely obviate the necessity of trial runs on the road to "break in" new engines. For this latter purpose the truck and trailing wheels also rest upon supporting wheels, which are driven by belting so as to revolve the engine wheels and wear their new journals and brasses to a proper bearing. At none of these plants, however, have such complete and varied comparative tests been made on locomotives of varied character and design as were made at St. Louis.

Turning now to the actual work done on the St. Louis plant, a general summary of the results of which is given in another column, twelve locomotives were selected, and the original scheme was for 16 to 20 tests with each of these, but the number of engines actually tested was eight, and the series of tests had to be modified to suit limitations of time and plant. In selecting the engines, the aim was to secure variety in the essential principles of design, the limits of time available preventing consideration of minor details, and the main object being to establish the economic performance of a number of typical locomotives when operating under a wide range of conditions. The engines tested included four freight and four passenger engines. Neglecting the immense 14-wheeled engine (2-10-2) as being exceptional, we have direct comparison between three large freight engines of the widely-used consolidation (2-8-0) class; two of these are simple and the third a two-cylinder compound engine. All the passenger engines were of the Atlantic (4-4-2) class, and all were four-cylinder balanced compounds, but on four different systems of compounding, as shown by the article in another column. Two of these are directly comparable, as modern American locomotives; of the others, one was of French and the other of German design and construction, the latter being equipped with a superheater.

A general review and summary of the results of the tests is given in another column, and need not be further considered here, except in regard to two points—first, the comparison of simple and compound freight engines; second, the comparison of compound passenger engines with and without superheaters. In regard to the freight locomotives, the report shows that the comparison is very favorable to the compound engine; the poorest compound shows an average saving in coal of 10% over the best simple engine, while the best compound shows nearly 40% saving over the poorest simple engine. The coal consumption per dynamometer horse-power at slow speeds is from 3½ to 4½ lbs. per hour for the simple and 2 to 3¾ lbs. for the compounds; while for high speeds the figures are 5 lbs. per hour for the former and 3.2 to 3.6 lbs. for the latter. The only compound tested at high speeds was a two-cylinder engine, which showed a very high efficiency under all conditions; but it is to be noted that two-cylinder compounds are not

now being extensively used in this country. It is stated, however, that the advantages of compounding decrease as the speed is increased, and in reconciling the high results for the compound the report points out that the conditions of the test were continuous operation at constant speed and load, were all favorable to the compound system.

Analyzing the numerous tests of the three consolidation engines, we obtain the range of figures noted below:

	Simple.	Compound.
Boiler H.P.	322 to 891	324 to 799
Indicated H.P.	300 to 1,098	442 to 1,040
Drawbar pull, lbs.	8,666 to 22,000	9,102 to 24,105
Dry coal per sq. ft. of grate per hour, lbs.	22.7 to 139	20.40 to 55.97
Dry coal per I. HP.-hr	2.91 to 5.40	2.01 to 3.82
Dry steam " " "	23.43 to 30.11	19.54 to 24.43
Best performance:	(1) (2)	(3)
Steam, lbs per I.HP.-hr	23.43 23.92	19.54
I. HP.	975 1,053	840
Cut-off	31.3 27.37	45.7
Speed, miles per hour	20 30	15

Taking now the question of superheating, it is difficult to present any definite or conclusive statements, since the only engine equipped with a superheater was a German engine, much lighter than the American engines tested and not designed for American coal or in accordance with American practice; it was also over-cylindered, as compared with American practice. There were no simple passenger engines tested, but all were four-cylinder compounds; those using saturated steam consumed from 18.6 to 27 lbs. of steam per Ind. HP. per hour, while in the one fitted with a superheater this was reduced to 16.6 lbs. of steam at 181° of superheat. The superheat ranged from 161° to 192° F., and did not appear to be affected by different rates of combustion or evaporation, but as the superheated steam passed through a dry-pipe surrounded by saturated steam of from 150 to 190 degrees lower temperature, it is evident that it would lose a considerable proportion of its superheat. The superheat in the branch pipe ranged from 71.28° to 116.20° F. It is noted that the quality of steam in the dome was exceptionally high, the moisture never exceeding 0.51%. The results as to steam consumption of the four engines may be summarized as follows:

	A. T. & S. F. Ry.	N. Y. C. & H. R. Ry.	German.	French.
Best Performance:				
Steam, lbs. per I. HP.-hr.	19.41	19.60	16.60*	18.60
Cut-off, h.p. cyl.	50.5	36.3	43.2	39.1 (l.p.60)
Speed, miles per hour	37.5	37.5	37	19.14
Indicated H.P.	1,296	967	729	495
At Max. Speed:				
Steam, lbs. per I. HP.-hr.	20.73	23.51	21.29†	27.05
Cut-off, h.p. cyl.	47.7	41	35.8	29.2
Speed, miles per hour	65.77	75.05	65.05	67
Indicated HP.	1,460	1,336	688	682

*With 181° superheat. †With 171½° superheat.

In conclusion, it may be said that the work at St. Louis represents the most comprehensive and extended series of comparative tests of locomotives that have ever been conducted. The results are of definite practical value, and the Pennsylvania R. R., its motive power officers and its advisory committee may be congratulated upon the successful completion of this important work.

LETTERS TO THE EDITOR

A Simple Method of Adjusting the Horizontal Wire in Transits Used for Leveling.

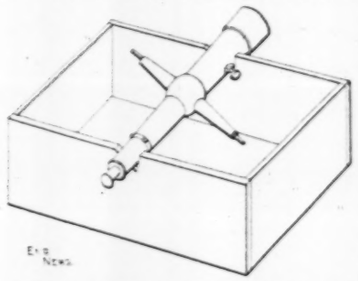
Sir: In nine out of ten transits in use the horizontal wire will be found somewhat out of adjustment when tried on long and short sights for leveling. It is a very tedious operation to correct this fault, which is primarily due to the horizontal wire being out of the line of collimation of the instrument.

Transits having no adjustment for the object slide cannot be corrected if the slide does not move the object glass parallel to the optical axis and line of collimation. Those having the adjustment for the object slide can be easily corrected by the method herewith described, which, though it assumes a cylindrical form for the telescope tube, yet gives results of substantial accuracy.

The principle of this adjustment is the same as that used for the adjustment of line of collimation in wye-levels, and undoubtedly engineers have often wished for a similar adjustment of the transit of equal simplicity.

As we have never seen this described in any books giving methods of adjustment, we believe from our experience with it that it will be appreciated by engineers, especially in localities remote from the instrument maker and where the transit must be used for good leveling.

To make the adjustment, the telescope is removed from the standards, and placed in a notched box of suitable



size in the manner illustrated. Then with telescope focussed on a distant point, it is rotated and the wires brought to remain on a selected point.

The same is done for short focus, and the guide for object glass adjusted if necessary. When the intersection of the wires remains stationary both for long and short focus the telescope is replaced in the standards; the vertical wire is then finally adjusted by the usual method of reversals, care being taken to leave the horizontal wire undisturbed. The level bubble is then made parallel to the line of collimation, as determined by the horizontal wire.

A trial of this simple expedient will convince the engineer or surveyor of its value, and will probably discover unsuspected causes for errors.

Rae & Collins.

No. 221 Tenth St., Portland, Ore., Jan. 18, 1906.

A Proposed Method of Tunnel Construction by Sinking Caissons End to End.

Sir: In your issue of March 28, 1901, you did me the honor of quite a lengthy description of a subaqueous viaduct that I proposed for use under navigable waters, particularly for the projected crossing of the Pennsylvania R. R., at New York city. The engineers of that road have seen fit to adopt the regulation underground tunnel—but that is another story. I have thought that your readers might be interested in a modification of the scheme that was looked upon as such a novelty at the time of your first publication.

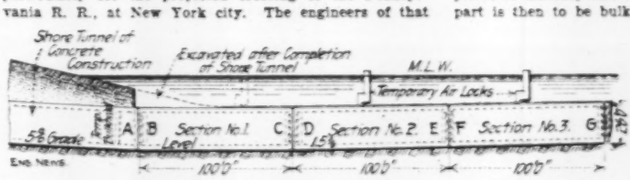


FIG. 1. SKETCH SHOWING MANNER OF PLACING AND CONNECTING SEPARATE TUNNEL CAISSONS.

Just now we are interested in a railway project for crossing a river that is noted for its shifting, uneasy, sandy bottom. The depth of water is not such as would permit of building piers that would anchor a tube-like, subaqueous bridge. Unless the old way of boring under the river be resorted to, the only thing to do is to dig a trench and then sink into it some form of tube or other subaqueous viaduct, the structure to be made in sections and laid in this trench much as one would lay lengths of sewer pipe or water main. There, too, great difficulties are presented. In this particular river a slight disturbance of a few hours is sufficient to undo anything in the way of trenching that may have taken weeks to perform. Necessity being the mother of invention, it was finally decided to build a tube as shown by the accompanying illustrations, a two-track, reinforced concrete affair, made in sections, merely laid on the bottom and gradually worked down into place, virtually each section a pneumatic caisson.

The body of the tunnel, that portion of it for the river crossing, is to be built on shore, of reinforced concrete, in 100-ft. sections, and launched into the river from ways similar to those used for launching ships. As very little shop work is necessary, it is proposed to build these sections on the river bank at the very site of the tunnel. Each section is to be provided with a temporary wooden bottom and end bulk heads, to admit of its being floated into position. In portions of the river where the water has a depth of less than 14 ft., lighters are to be used, while the sections for the end having shallow water will be built opposite the line of tunnel to admit of their being launched directly into the partially excavated trench.

Each section is, in itself, to form a pneumatic caisson, supplied with air locks, compressors, etc. As soon as a section is in its proper location of alinement, and an air pressure can be maintained in it, the bottom, with the exception of the trusses which also act as ties, is to be removed and the section sunk in the ordinary manner of putting down a caisson, by laborers excavating to the necessary depth. The shifting of sand and other natural disturbances of the river will thus have absolutely no effect upon the work, no open trenches to be filled up nor sheet piling to be resorted to. Guide piles merely will be provided to insure the sinking of the tube within, at least, a foot of absolute alinement. Such extra weight as may be required to sink the caissons is to be built on top of each and then removed to the next, as the river bottom shall have filled in closely about the completed section.

In a longitudinal direction the sections are to be sunken as closely as possible, what little space remains between them is to be filled with concrete while under air pressure, or, if this proves impracticable, the freezing process may be used. The concrete sections can, of course, be given any desired slope at the ends to provide for changes in the grade of the tunnel. From the deep water end, the process of setting and connecting the tunnel ends will be thus: The shore portion of the tunnel is to be first completed of masonry and concrete in the usual manner. This part is then to be bulkheaded a few feet back from the river bank, temporary bulkhead A. Section 1 of the tunnel is to be next sunk in place as close as possible to the completed end and a splice made with it under pressure, bulkhead B of Section 1 being removed as soon as the proper depth is reached. Section 2 is then sunk, the air-lock remaining on Section 1, and bulkheads C and D removed, and connection made between Sections 1 and 2 as before described. The opening for the air-lock on Section 1 is then sealed and the lock removed by divers. In a similar manner Section 3 is to be sunk and connected, though a portable bulkhead should be used and moved forward as fast as possible in order to avoid the expense of maintaining air pressure on a great length of tunnel. Of course, before the air pressure is removed, the concrete bottom, with the steel ties, is to be put in with drains, etc., as shown in Fig. 2.

The entire structure is to rest on the sand bottom, the latter forming a continuous foundation for the structure. A depth of 20 ft. is to be allowed above the tunnel top for navigation. In places this will be above the natural bottom of the river, and in other places well below bottom. Where it is thus exposed to the action of the water no extra precautions are needed, the 2½ ft. of concrete being quite sufficient for strength as well as to make it com-

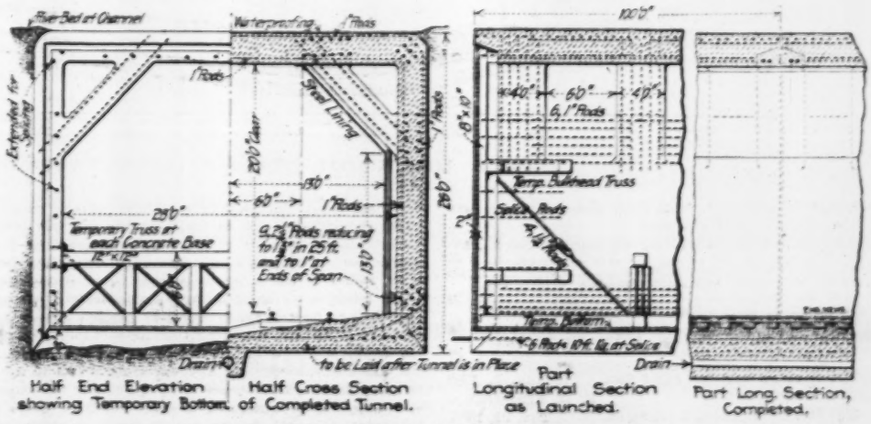


FIG. 2. DETAILS OF CAISSONS FORMING TUNNEL.

pletely waterproof. The top and sides, however, are to be thoroughly waterproofed before each section is placed in the water, and when the tunnel is all set in place the inside is to be lined with steel sheeting, after the face is asphalted and otherwise waterproofed.

The drawings show the method of bracing, the cutting edge of the caisson, the temporary bulkheads, the rough trusses across the bottom, and the details of the structure sufficiently without further technical description. The placing of the rods and the design in general amply provide against distortion from the very great variety of external and internal pressures and loadings to which the structure will be exposed during the course of construction. No attempt has been made, or is deemed necessary, to provide for possible enlargement. If traffic warrants additional room then another two-track tube may be laid alongside of this one, and so on, and without interfering in any way with the operation of the first tube.

While the general scheme is really a development of our old subaqueous viaduct idea, the credit of devising this pneumatic caisson, as a weapon to use against the very troublesome bottom, is due to Mr. F. W. Lepper, Assoc. M. Am. Soc. C. E., of Cleveland, O., the well-known Government structural engineer who likewise devised most of the splendid structural work of the Chicago post-office, whose dome is certainly the finest piece of structural engineering in the country.

This particular form of what might be called a tunnel is without question the cheapest means for a railroad crossing of navigable waters. It has no draws to maintain as does a bridge, nor has it the exaggerated grades required for a bored tunnel. It impresses me as an admirable solution of the question, and the cost of a structure of such dimensions is the least of any form of crossing I know of. The tunnel proper is 26 ft. clear width and 20 ft. clear height at the center of the tracks, and the cost is estimated as follows, and the figures are liberal, the very maximum cost:

Launching, towing and sinking, complete, per lin. ft..	$95
Concrete, per lin. ft.	65
Steel rods and ties, per lin. ft.	50
Temporary trusses, bulkheads, framing, divers, etc., per lin. ft.	30
Waterproofing, steel lining when finished, etc., per lin. ft.	20
Pumps, ventilation, drainage, wiring for the lights, etc., per lin. ft.	30
Total actual cost per lineal foot	$290

F. W. Fitzpatrick.

4200 14th Street Road, Washington, D. C., Jan. 22, 1906.

(Our readers will be interested to trace the similarity between this project and the work now being actually carried out in the construction of a tunnel under the Seine, in Paris, described on another page of this issue.—Ed.)

Notes and Queries.

Mr. James H. Harlow calls our attention to an error in connection with the paper "Power Plant Economics," by Mr. H. G. Stott, printed on pp. 148 to 151, of our issue of Feb. 8. In Fig. 11 of that paper, on p. 151, the ordinates giving "Fixed Charges per Kilowatt-hour" appear to be given in cents, but the scale actually corresponds to dollars. That is to say, at load-factor 0.2 the fixed charges per kilowatt-hour is $0.12 \times \$130 \div 1{,}752 = \$0.0089 = 0.89$ ct. for the upper curve, and $0.12 \times \$90 \div 1752 = \$0.0062 = 0.62$ ct.

A Bloomfield, N. J., correspondent desires to be informed whether the term "antilogarithm" is in general use among engineers and what is the accepted meaning of the term. An antilogarithm is the natural number corresponding to a given logarithm; thus, the (Briggs) logarithm of 20 is 1.30103, and the antilogarithm of 1.30103 is 20. The chief use of the term antilogarithm is in instruction. Short tables of antilogarithms have been compiled (also for school instruction), in which the first column contains decimal numbers, say to three places, which represents mantissas; the next column gives the antilogarithm, which, in this case, would be a continued number. Engineers have no need for either the term antilogarithm or table of antilogarithms.

THE COMPULSORY USE OF WATER METERS in all cities and towns deriving any part of their water supply from drainage areas outside their municipal limits is provided for by a bill recently introduced in the Massachusetts legislature. It is said that the bill has been brought in at instance of paper manufacturers in the central part of the state, who, although recognizing the prior rights of public water supplies, urge that water power interests are being damaged by unnecessarily large diversions to meet demands caused by absolute waste. At a hearing on the bill municipal authorities admitted the desirability of selling water by meter measurement, but urged that meters are now being introduced as rapidly as water-works revenues warrant and that to compel every service to be metered at once would be a great hardship. A second hearing will be given, at which the manufacturing interests will be heard.

THE PROPOSED TUNNEL UNDER THE DETROIT RIVER FOR THE MICHIGAN CENTRAL R. R.

Construction work will soon be in progress on a second railway tunnel crossing of the Detroit River. In 1890 the Canadian and American lines of the Grand Trunk Ry. were physically connected across this important waterway by a tunnel at Sarnia. Previously a car ferry had been necessary to transfer trains from one shore to the other. Such a ferry still continued in use for the other great international line, the Michigan Central R. R. The thought was always in mind, however, that ultimately the physical connection of the lines should be made perfect by bridge or tunnel. At first attention was directed chiefly toward a bridge crossing, but lately the company's engineers gave most of their study to a possible tunnel crossing, and this is the type of crossing that has been finally decided upon and that is soon to be put under construction, unless all present plans go seriously awry.

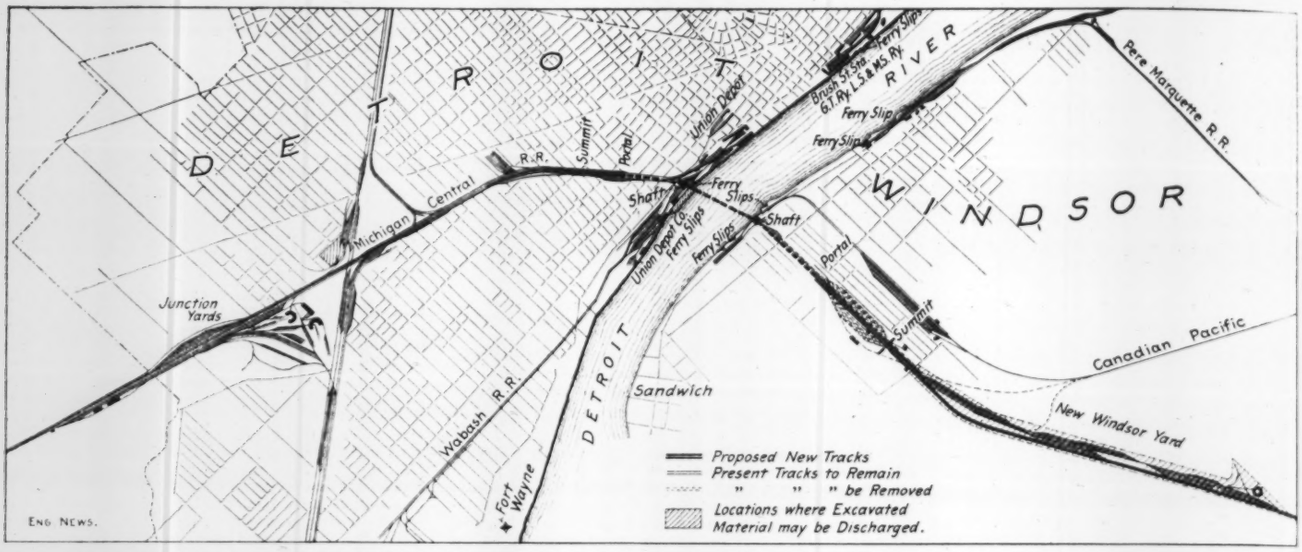


FIG. 1. MAP SHOWING ROUTE OF MICHIGAN CENTRAL RAILWAY TUNNEL ACROSS THE DETROIT RIVER AT DETROIT, MICH.

As soon as a tunnel crossing had been decided upon a special organization, known as the Detroit River Tunnel Co., was brought into being to carry out the work. This company immediately began with a large force of engineers to prepare plans, and such progress was made that designs and specifications were virtually completed late in 1905, and on Feb. 1 of the present year they were in final shape for asking bids for construction. It may be noted that all this work and that all the remaining work of design and construction comes under the direction of an Advisory Board of Engineers, composed of Mr. W. J. Wilgus, M. Am. Soc. C. E., Chief Engineer New York Central & Hudson River R. R.; Mr. Howard A. Carson, M. Am. Soc. C. E., Chief Engineer Boston Transit Commission, and Mr. W. S. Kinnear, formerly Chief Engineer and now Assistant General Manager Michigan Central R. R. Mr. Kinnear will have charge of the tunnel work as Chief Engineer after contracts are let.

In order to widen the field of bidders and enable such a free presentation of ideas as would lead to

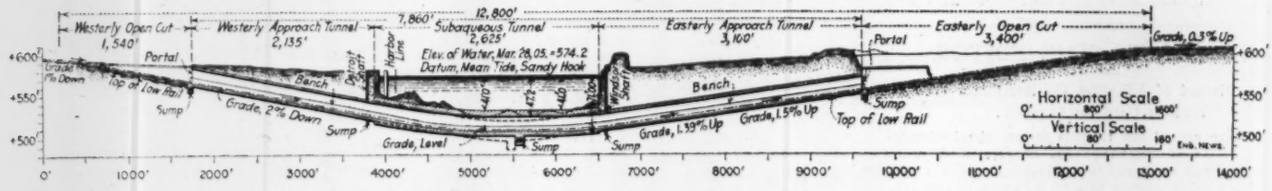


FIG. 2. LONGITUDINAL PROFILE OF DETROIT RIVER TUNNEL.

the utmost reduction of hazard and increase in speed and economy of work, a scheme somewhat unusual in preparing contract drawings for tunnel work was adopted. Alternative designs were worked out, any one of which the bidder is free to choose, and, in addition, he is invited to present plans of his own, should he wish to do so. With these preliminary explanations, the description of the plans may be taken up.

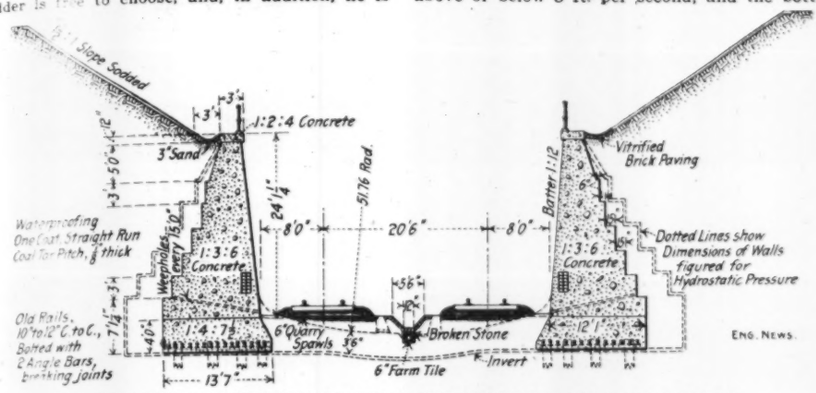


FIG. 3. TRANSVERSE SECTION OF OPEN CUT APPROACH NEAR EAST PORTAL OF TUNNEL.

GENERAL DESCRIPTION.—The map Fig. 1 shows the general layout of the proposed tunnel line and the track and yard work to be done in conjunction with it. It will be noticed that the existing alinement is not materially changed, the tunnel passing under the river at the present ferry crossing. In fact, the line work throughout is clearly explained by the symbols and captions. The alinement of the tunnel proper is indicated in a general way by Fig. 1; briefly, there is a straight section or tangent on each shore, and under the river a third tangent, which is connected with the shore tangents by 2° curves.

The longitudinal profile of the tunnel is slightly different for each tube, and also differs somewhat for different designs. The drawing Fig. 2 shows the profile along the center of the west-bound track tube, which, being the outside tube on the curve, is 5.46 ft. longer between portals than is the inside tube, or the tube for the east-bound track. The profile shown by Fig. 2 is that for design A; the profiles for designs B and C are almost identical with that for design A, but the profile for design D is slightly different, the tubes being deeper under the river bed and the relative lengths of approach tunnels and subaqueous tunnel being changed. For comparison, design D profile has been drawn in dotted outline on Fig. 2, which thus indicates all the essential details in longitudinal profile of all four designs.

The tunnel will penetrate a mixture of blue clay and sand for its entire length. This material was determined by churn drill borings made one on each side of the line every 100 ft. of its length between the ends of the approach retaining walls and by four test pits, one close to the water's edge on each side of the river and one further inside on each side. The borings were made with a churn drill working inside a 2½-in. diameter casing while water was being forced through the 1 11/16-in. diameter hollow drill bar. In addition to observing and recording the wash samples, the resistance to penetration of the drill was observed and core samples were taken in many of the holes at points contiguous to the tunnel bore. According to the resistance to penetration records, the clay at the depth of the tunnel bore is classified as soft. Judging from the test pit records, however, it appears to be a medium to stiff blue clay, with a varying and at no time large content of sand and gravel. According to the test pit observations also, this clay gave very little water; a considerable flow came from the sand and gravel strata above the clay bed and from the sand stratum at the bottom of the river.

As certain of the proposed designs call for stagings in the river, the sinking of sections of steel or timber forms, and the depositing of concrete through the water, careful observations were made of the current velocities. Considerable irregularity is shown by the meter readings, which were taken at four or five depths about every 200 ft. across the river; but, generally speaking, the surface velocities were slightly above or below 3 ft. per second, and the bottom velocities were from 1.17 ft. to 2.29 ft. per second.

Returning to the profile Fig. 2, it is to be noted that the open cut approaches and the approach tunnels are the same in construction for all four designs, except that in design D they are of somewhat less length than in the other designs. The subaqueous tunnel construction is, however, different in each design.

LAND TUNNELS AND APPROACHES.

Designs A, B and C all call for a 1,540-ft. open cut and a 2,135-ft. approach tunnel on the west shore and a 3,400-ft. open cut and a 3,100-ft. approach tunnel on the east shore. In Design D the open cuts are of the same length as in the other designs illustrated by Fig. 2, but the west approach tunnel is only 2,069 ft. long and the east approach tunnel only 3,007.34 ft. long. Except for this difference, the open cut and the approach tunnel construction is the same for all designs.

OPEN CUT CONSTRUCTION. — The open cuts flanking the tunnel proper at each end call for brief description only. They are simply earth cuts, with 1 on 1½ slopes in the shallower portions and retained banks in the deeper portions. The cross-section Fig. 3, taken near the portal on the east shore, indicates clearly the retaining wall construction. This drawing shows a concrete invert between walls and bracing them apart; this invert extends 306 ft. from the east tunnel portal and 745 ft. from the west tunnel portal. Beyond the ends of inverts the walls are braced apart ("where directed by the engineer") by struts consisting of steel rails embedded in concrete, spaced 15 ft. apart. Practically the only other general detail not shown by the drawing is the cutting of the walls vertically by transverse tar-paper joints every 50 ft. to provide for expansion.

APPROACH TUNNELS.—The two approach tunnels are substantially identical in construction. Each consists of two single track tubes separated by a concrete center wall and lined with concrete, which shall or shall not be reinforced, as the engineers direct. The drawing Fig. 4 shows a normal section. This section happens to be at a point where a cross-passage and the conduit splicing chambers are cut. The cross-passages occur every 200 ft., and the splicing chambers every 400 ft.; between these openings the center wall and benches are solid concrete embedding the ducts. Referring to the drawing Fig. 4, attention may be called to the cable holes connecting with the splicing chambers and to the slots for cross-ties in the concrete floors. The other details are sufficiently clear from the drawings.

The method of constructing the approach tunnels will be determined by the contractor, subject to the approval of the engineer.

SHAFT CONSTRUCTION.

To facilitate construction, the contract plans provide for a shaft on each side of the river; the locations of these shafts are shown in Figs. 1 and 2. The design is practically the same for both shafts, and is indicated clearly for the west shore shaft by Fig. 5. As will be seen, a very substantial structure of concrete is planned, since it is to serve as a permanent shaft after construction is finished.

RIVER TUNNEL PLANS.

The contract plans offer four designs of tunnel for the portion of the work coming under the river. These are designated as trench methods A, B and C, and shield method D. In addition, the bidders are permitted to present plans of their own, should they choose to do so. Each design is described separately in the following sections from information given in the specifications:

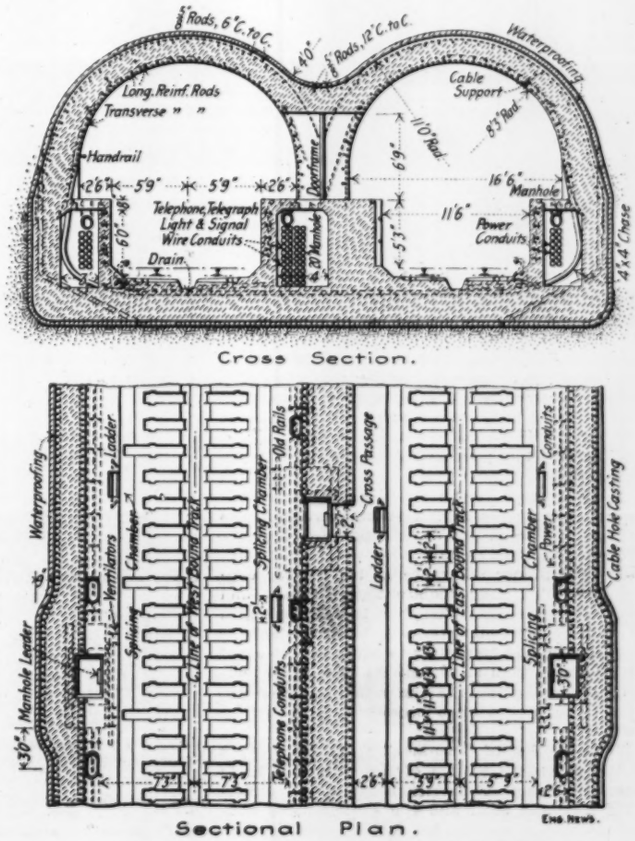


FIG. 4. TRANSVERSE SECTION OF APPROACH TUNNELS.

DESIGN A, TRENCH METHOD.—The design shown in the profile Fig. 2 and the cross-section Fig. 6, known as Design A, is one suggested by Mr. W. J. Wilgus, of the Advisory Board of Engineers, who states its advantages to be "reduction in lift of traffic, saving in time of construc-

tion, minimizing of risks and large saving in first cost." It may be briefly described as a method by which the pervious material underlying the river is replaced by an impervious concrete placed under water, through which, without the use of shields, the inner tubes or tunnel proper may be constructed so as to secure water tightness, continuity of strength and good workmanship, with an absence of high air pressures. It will also be noted that this method dispenses with the use of cofferdams. The progressive stages for this design are:

(1) Dredging a trench for the approximate dimensions shown by Fig. 6. While certain slopes are assumed as proper for the purpose, the contractor is expected to inform himself on this point and make proper allowance in his bid for contingencies that may require flatter slopes, and therefore more excavation than is indicated upon the plan. The contractor will be given latitude as to the method he prefers to adopt in the use of flatter slopes than shown on the plan or of temporary sheet piling for the retention of slopes within the approximate cross-section shown on the plan.

(2) Depositing of "two-men" stone for a depth of 18 ins. on the bottom of the trench, so as to form a blanket or barrier between the underlying clay and sand and the superimposed concrete.

(3) The construction of temporary platforms in accordance with the permits of the United States and Canadian governments, upon which the contractor's machinery, including mixers, etc., may be placed for the operations herein described; said platforms to move progressively across the river as the dredging and other work permit.

(4) Depositing of concrete by the tremie, bucket or other process approved by the engineer for a depth of approximately 2 ft.

(5) The placing of saddles with the aid of blocking and wedges upon said bed of concrete, upon which the forms are to be placed as herein described. As an alternative method, piling may be driven after the trench is excavated and cut off at a proper height to receive the saddles, so as to dispense with the use of blocking and wedges.

(6) The construction on shore and floating into position of forms coupled together in pairs or otherwise, consisting of timber or steel, as preferred by the contractor, in convenient lengths of from 50 to 500 ft., and gradually sunk into correct position on the saddles above described.

(7) Placing under, around, between and on top of the forms concrete by the bag, tremie or bucket process, as may be determined by the engineer during the progress of the work as best qualified to insure good workmanship, so as entirely to encase the forms with concrete in the manner shown by Fig. 6. The option is left to the contractor of either joining adjacent forms under water in such a manner as to secure [illegible] connections or of leaving an open space [illegible] them to be filled with concrete as above [illegible] so as to act as a bulkhead separating [illegible] cent forms, to be cut out after the [illegible] been expelled as hereinafter described.

(8) After the concrete placed under [illegible] had an opportunity to set thoroughly, [illegible] may be pumped out of the first section, [illegible] leakage is found to be excessive air may [illegible] of a sufficient pressure to enable the wat[illegible] to be perfected and the inner tube or [illegible] be properly constructed.

(9) Should the contractor elect to a[illegible] steel for the forms, they shall be construct[illegible] watertight joints in such a manner that [illegible] the work, they will act as waterproofing [illegible] vent the percolation of water against the [illegible] of the inner tubes of the tunnel proper. Should the contractor elect to use wooden forms, waterproofing may be placed on the exterior of the forms before they are sunk into position, so that when the forms are removed the waterproofing will remain in place. This method will require the use of air pressure to prevent hydrostatic pressure from distorting the waterproofing.

(10) After proper measures have been taken to make each section thoroughly watertight, the inner tubes of the tunnel proper shall be constructed with metal reinforcing in the manner and of the classification of concrete shown on the plans.

DESIGNS B AND C, TRENCH METHOD.—Design B may be briefly described as a method by which the inner tubes of the tunnel proper are first built in floats or on dry land, floated and sunken into position on a proper foundation and joined together by a suitable method, so as to secure continuity of construction and watertightness. This design was suggested by Mr. H. A. Carson, of the Advisory Board of Engineers, and is shown by Fig. 7. The progressive stages for this design are:

(1) The dredging of a trench, the depositing of "two-men" stone, the construction of a temporary platform, 2-ft. bed of concrete and the placing of saddles in the same manner as described for Design A.

(2) The tubes, after being floated into position, are to be gradually sunk to a proper bearing on the saddles and a proper joint made at the connection of the tubes, so as to insure watertightness and an equality of strength with the remaining portions of the tube, so that the joint will not be an element of weakness in the structure and will be fully as strong as any portion thereof.

(3) Around, between and under the lower portion of the tubes is to be placed the concrete as shown by Fig. 7.

(4) Above the concrete and around and on top of the tubes is to be placed a back filling of suitable material approved by the engineer.

(5) On the top of the back filling is to be placed riprap as shown on the plan.

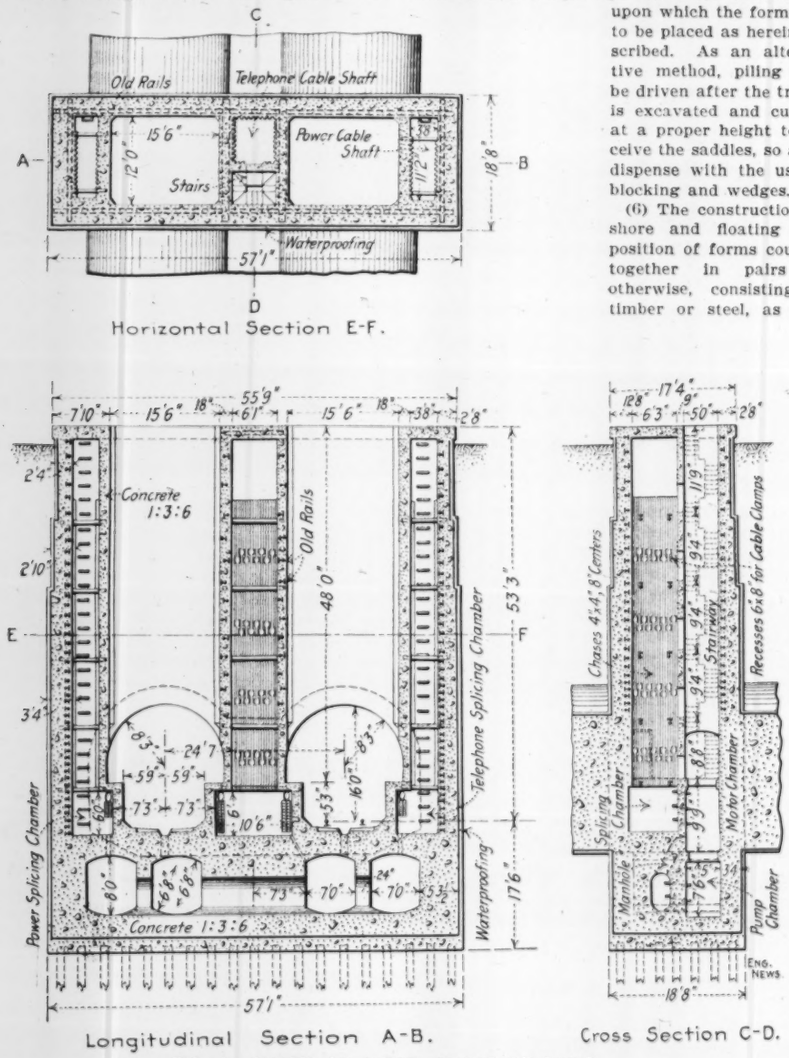


FIG. 5. SHAFT ON WEST SHORE OF RIVER.

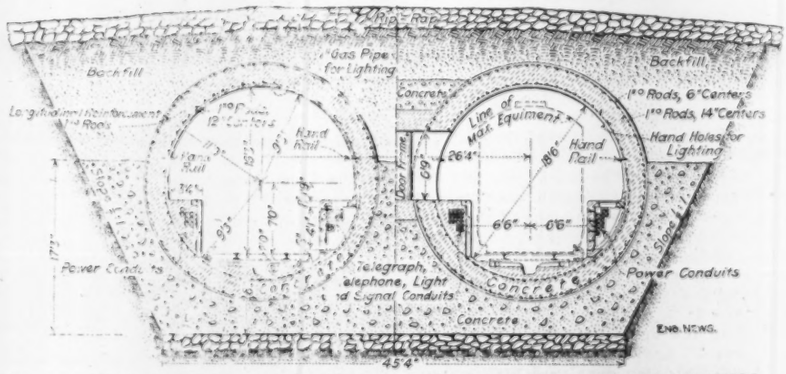


FIG. 7. CROSS-SECTION OF SUBAQUEOUS TUNNEL DESIGN B, TRENCH METHOD.

Design C is practically the same as Design A, with the exception of the details shown by Fig. 8, which prescribe a certain style of steel form and arrangement of reinforcement that differ from the arrangement of Design A, Fig. 6.

DESIGN D, SHIELD METHOD.—The option is given to bidders of selecting the well-known shield method of construction, Design D, if they do not feel warranted in bidding on other methods. The necessity, however, of retaining the summits of the tunnel gradients at the points shown on the plans fixes a location of the top of the tunnel for

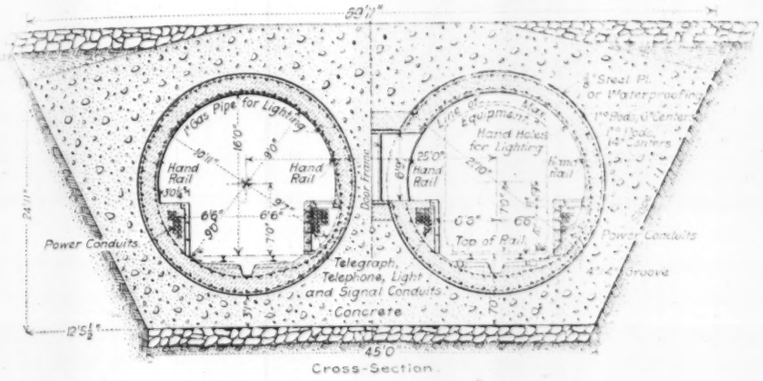


FIG. 6. CROSS-SECTION OF SUBAQUEOUS TUNNEL DESIGN A, TRENCH METHOD.

the subaqueous section so close to the river bed as to require artificial filling in order to hold air by the shield method. Therefore, the contractor bidding upon this method must bear in mind the necessity of placing temporary blankets or masses of clay on top of the location of the tunnel, so as to give the necessary thickness between the top of the shield and the water, to prevent or reduce the escape of compressed air. Fig. 9 is a cross-section of the shield-driven tunnel, and its profile is shown by dotted lines on Fig. 2.

METHODS OF CONSTRUCTION.

The contract plans specify materials and general methods of construction, and some of the clauses relating to methods of construction, and particularly to the manner of conducting work by the trench method, are of importance and novelty enough to abstract briefly.

DEPOSITING CONCRETE.—The large amount of concrete to be deposited under water is a distinctive feature of all the designs by the trench method. The method for depositing this concrete may consist of a selection of the tremie properly designed to fit local conditions, drop-bottom buckets or bags. If tremies are used, they shall be constructed of steel, handled by power, so as to be easily adjusted in moving from place to place, and designed so as to give a slow, uniform movement of the mass in passing from the mixing platform to the point of deposit. As a rule, the tremie shall first be filled with concrete, which shall be allowed to escape slowly at the bottom, with the aid of a diver, concrete being placed in at the top as fast as it passes out at the bottom. In this manner the only point where there is danger of washing away of the cement from the aggregate is in the adjusting of the concrete from the bottom of the tremie to its final position. Care shall be taken by the diver that the concrete has no fall through the water, but oozes out so as to cause a minimum disturbance of the material. In passing under and around the tubes it may prove necessary to have curved adjustable lengths provided at the bottom of the tremie for depositing the concrete in places that would be inaccessible for straight tubes.

Where drop-bottom buckets are used, they shall be filled on the mixing platforms and the tops closed, so as to prevent the washing away of the cement in passing through the water. They shall not be dumped until the bucket is close to the point of deposit, so that the concrete will not fall through the water.

Where bags are used, the concrete shall be placed therein on the mixing platforms and lowered to the diver, who shall pack them closely into position, so that the cement oozing through the mesh of the bags will bind the entire mass together.

The proper one of the three above methods shall be adopted, with the approval of the engineer, to best fit conditions as they arise. For instance, in order to prevent an uplifting effect on the tubes and to guarantee a continuous and thorough support for the underside of the tubes, the engineer may require the use of bags instead of the tremie or bucket method for that portion of the work. Where cavities exist beneath the lower semi-circumference of the forms, the holes that have been provided in the forms shall be opened and grout shall be forced into the surrounding materials by means of a suitable machine, which will mix the grout continuously and permit the application of a pressure of 60 lbs. per sq. in. in excess of the water pressure. Sufficient grout shall be used to fill all voids that can be detected from the interior of the forms.

STEEL FORMS FOR DESIGN A.—If steel forms are selected by the contractor, they shall be suitably internally braced, so as to prevent distortion in the process of floating into position and sinking on the saddles and to prevent injury during the placing of the exterior concrete and after the water has been exhausted from the interior thereof. The contractor has the option of using several different methods of preventing the distortion of these forms, by various types of interior bracing or by means of vertical pipes projecting far enough above the level of the river surface to cause a hydrostatic pressure on the forms that will prevent distortion; or, in lieu thereof, the use of pumps to cause the same effect. It is expected that with suitable methods of bracing and the hydrostatic method above suggested it will be possible to make these forms in length as great as 500 to 600 ft., although convenience in the process of sinking may cause the contractor to prefer shorter lengths.

All joints in the tubes shall be thoroughly ship-caulked, so that when pumped out the forms will be watertight under maximum hydrostatic pressure. It is expected that the forms will be deposited in exact position, so that the thickness of the interior tubes or tunnel proper, as shown on the plans, may be obtained, but provision has been made for a maximum variation of 3 ins. Therefore, special precautions will be required to prevent distortion or improper placing of the forms.

Should the contractor elect to join abutting forms under water, so as to secure watertight joints, temporary steel bulkheads should be provided, so that in case of accident the completed portion of the tunnel will not be affected. If, however, the contractor elects not to join abutting forms under water, sufficient separation shall be allowed to secure a bulkhead of concrete placed under water in conjunction with the placing of the remainder of the exterior concrete, which may be cut away as the work advances. After this bulkhead has been removed steel sleeves of the same thickness and design as the forms shall be inserted, lapping a suitable distance into each of the abutting forms, with the joints thoroughly caulked to the satisfaction of the engineer, so as to form a continuous watertight structure. Suitable frequent holes shall be provided, closed with screw plugs, through which grout shall be forced when required by the engineer, to fill cavities that may remain between the outside of the lower semi-circumference of the forms and the exterior concrete.

WOODEN FORMS FOR DESIGN A.—If wooden forms are selected by the contractor, the designs therefor, including the saddles, shall first be submitted to the engineer for his approval. The contractor may have a selection of two methods of placing the waterproofing in connection with these forms, either by placing the same in connection with waterproofing on the exterior of the forms before they are launched and floated into position and filling cavities with grout as described for steel forms, or waterproofing may be placed on the face of the exterior concrete after

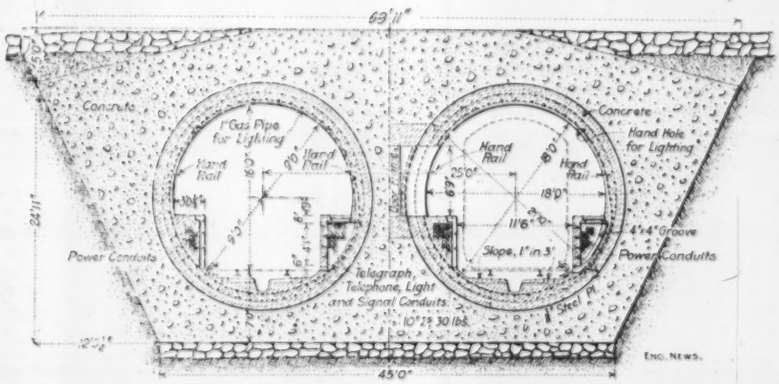


FIG. 8. CROSS-SECTION OF SUBAQUEOUS TUNNEL DESIGN C, TRENCH METHOD.

the wooden forms have been removed and cavities filled with concrete to present a smooth surface on the intrados. In either case the engineer will require that the waterproofing shall be first class in every respect and continuously watertight before the placing of the interior tube or tunnel proper is permitted. With the use of wooden forms, it is expected that compressed air of moderate pressure will be required to repel leakage, so as to permit the placing of the waterproofing and the holding of the same in position pending the construction of the interior tubes.

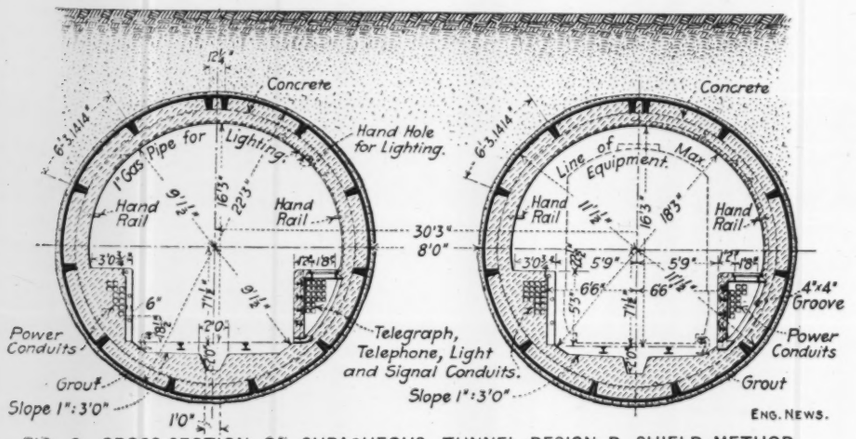


FIG. 9. CROSS-SECTION OF SUBAQUEOUS TUNNEL DESIGN D, SHIELD METHOD.

STEEL FORMS FOR DESIGN C.—The forms for Design C are shown in detail upon the plan, and are to be connected under water in such a way as to make watertight joints. A number of alternative plans have suggested themselves to the tunnel company, but it has been deemed best to leave this detail to the contractor, selecting this method upon which to make his bid. A description and plan of the contractor's method of performing this detail should accompany his bid.

DESIGNS A AND C.—The inner tubes or tunnel proper for Designs A and C will consist of concrete of the classifications and dimensions shown on the plan, including splicing chambers, cross-passages, bench walls, track construction, single-way ducts, hand rails, gaspipe conduits for electric lighting, steel reinforcement and all other work incidental thereto. This work will be performed in the dry in sections, after the forms have been placed and made thoroughly watertight to the satisfaction of the engineer. It is expected that the lining will be laid continuously, so that with the aid of the metal reinforcement the inner tubes will be homogeneous and of uniform strength from end to end.

DESIGN B.—For Design B the tubes will be constructed in floats or on shore, in suitable lengths, of the classifications of concrete shown on the plan, with metal reinforcement and temporary bulkheads. The tubes are to be tested by exhausting the air therefrom, or by any other approved method to make reasonably sure that they are watertight. The tubes will then be floated into position and gradually sunk until they reach a bearing upon the saddles that have been previously placed. Each tube as it reaches a bearing will be brought into as close contact as possible with the one that has been previously placed; the joint shall be made entirely watertight, and the tubes connected in a manner that will give as great a degree of strength at the joint as in the body of the tube. In other words, the joint shall not be an element of weakness in the finished tubes, either as regards watertightness, durability or strength.

SHIELD METHOD.—The number of shields employed shall be large enough to permit work on at least two faces at once. The shields are to be erected in shield chambers, which shall be an enlargement of the regular section of the tunnel adjacent to the shafts sufficient to permit the contractor to properly erect the shields. The bulkheads or stop-walls closing the spaces between the enlarged sections and the ordinary tunnel sections shall be formed either with special castings or with concrete, as the engineer may require. Before starting the shield forward after its erection, a standard cast-iron lining shall be built up temporarily within the enlarged section and within the tail of the shield to perfect shape, alinement and grade to start the permanent lining from and to form a thrust bearing for the shield. After moving the shield out of the enlarged section, all of the cast-iron lining thus temporarily placed shall be removed and the section filled in to normal cross-section, as shown on the plan.

The air shall be delivered into each heading through two supply pipes of such capacity that the velocity of air through them in regular working shall not exceed 40 ft. per second. These pipes shall be tapped with regulating valves in each intermediate air chamber in tunnels, and sufficient air admitted to ventilate it and to maintain the pressure required. If required by the engineer, air shall be delivered at the shield in each section or compartment thereof where men are employed, and withdrawn therefrom in special exhaust pipes, with suitable regulating valves.

A foul air vent pipe, 8 ins. in diameter, shall be carried back from the shield through each lock bulkhead to the ordinary atmosphere to ventilate the heading, and shall be provided with a 10-in. pressure regulating valve near the shield to maintain the pressure required; the valve shall be so placed as not to be readily tampered with.

Effective means shall be used to secure proper ventilation. The amount of carbonic acid at any working face in any chamber must never exceed one part in one thousand parts of air, and compressors must be run so as to maintain at all times a change of air through the pressure regulating valves. Suitable devices shall be used to deaden the noise of air introduced and exhausted as much as practicable. When blasting is resorted to special means must be provided for the rapid removal of the fumes produced.

Bulkheads shall be built in each tunnel at intervals not exceeding 1,000 ft., and there shall at no time be an interval of more than 1,000 ft. between a shield and the bulkhead nearest to it. They shall be of concrete or of brick set in Portland cement mortar. Each bulkhead shall be provided with two air locks near the bottom at least 6 ft. in diameter and 20 ft. long for the passage of men and materials, one near the roof as an emergency lock for the passage of men only and a pipe lock 12 ins. in diameter and 31 ft. long with a gate valve at each end for passing pipes and rails. The emergency lock shall be of ample dimensions to contain the entire force employed at any time at the heading. Stairways and galleries extending the full length of the forward air chamber shall always be maintained to give convenient access thereto and for the purposes of setting out lines and inspection. All parts of bulkheads and air locks must be of sufficient strength to sustain safely a pressure of 45 lbs. per sq. in.

CONCLUSION.

The contract plans specify in detail the character of all the material to be used in the work; these specifications conforming closely to the standard specifications of the New York Central & Hudson River R. R. for corresponding materials. Mention may be made of the fact, however, that all mixtures of concrete proposed to be used by the contractor shall be tested by being placed in vessels of the actual water in which its use is planned, where it shall set perfectly before being accepted.

RECORDING BENCH MARKS AND ELEVATIONS.

By Ernest McCullough.*

To avoid unnecessary duplication of work in different bureaus of the Departments of Public Work employing engineers the card system offers advantages. The writer has devised a card system for keeping track of bench elevations which may be of service to heads of bureaus.

He knows of one city where the Bureau of Water, the Bureau of Streets, the Bureau of Sewers, and one or two other departments have engineers working who depend upon unrecorded elevations in old field books, paying little attention to regularly established benches. It sometimes happens that each department uses the same points and the elevations differ slightly.

The system proposed calls for postal cards to be carried by each instrument man under a rubber band on the right-hand page of his field book. When he determines an elevation the elevation and the description of the point are to be placed on the card as well as in the book. At the conclusion of the day's work the card is dropped in the nearest mail box.

These cards are printed as shown herewith, and on the address side is the address of the Bench Engineer or the man having charge of such records.

The postal card gives the number and elevation of the starting point and then describes all turning points used that day which are stable enough to serve for bench purposes.

BENCH MARK POSTAL CARD.

No..... December 9, 1905.

BENCH ENGINEER.

Sir:

To-day I started from | permanent / temporary | bench No. *3672, Elevation 103,431* and established the following elevations:

105.79 Top of hydrant N. W. x Grant and 17th.

104.93 Top of hydrant N. W. x Grant and 19th.

99.212 N. E. cor. lowest step on Sherman St. entrance Bell Machine Shop.

Respectfully,

JOHN SMITH,

Asst. Eng. Water Bureau

[Portions in italics indicate written entries, others printed. Word "permanent" on postal card would be crossed out.—Ed.]

Each morning as the cards come in an assistant will mark a cross on a map so that the seeker for information can always tell within a block where a bench is to be found. Then the assistant makes a card for each bench and if the bench is at a corner, makes two cards. These cards are filed in a card index drawer in rotation so a man looking for a bench can readily find it.

BENCH MARK RECORD CARD.

BENCH RECORD.

Temporary Bench No. *4001.* From Card No.....

Elevation obtained by *John Smith, Water Bureau.*

Date: *December 9, 1905.*

Description of bench: *Top of hydrant N. W. x Grant and 17th.*

Elevation: *105.79 above datum.*

Elevation verified.....

.....

[Portions in italics indicate written entries, others printed.—Ed.]

This will do away with bench books and scrap book information in each department. The advantages of having all such information in one place readily available can be seen. A similar system can be used for temporary line points as well.

A modification has been suggested that in-

*Specialist in Municipal Improvements, P. O. Box 691, Chicago, Ill.

volves the use of cards of different colors, one for each month, and removing from the file all cards six months old, until the elevation can be verified. It will be noticed that the postal card has the word "Temporary" and the word "Permanent" printed on it. The benches are numbered consecutively and the word most clearly indicating the kind of bench will be allowed to stand, the other being scratched.

It is expected that when the city bench engineer establishes permanent benches anywhere that all temporary bench records in the files for a radius of two or three blocks will be removed and the use of such benches discontinued. To render this clear, it will be a good thing to indicate on the map all temporary benches in one color and permanent benches in another color. The temporary benches can be marked with a colored pencil, so the mark can be erased and the permanent bench can be marked with ink.

THE NEW ORLEANS MOSQUITO PREVENTION ORDINANCE.

A new mosquito prevention ordinance went into effect at New Orleans on Jan. 1, 1906. The ordinance was adopted by the City Council on Sept. 26, 1905, and approved on the following day by Mr. Martin Behrman, Mayor of New Orleans. As most of our readers will understand, the ordinance is designed to assist in the prevention of another yellow fever epidemic, like the one at New Orleans in 1905, and also to aid in putting down malaria, besides effecting a reduction in mosquitos in general and the annoyances caused by them.

The intended relation between the ordinance and mosquito prevention may be seen from the title of the document: "An Ordinance to Promote the Public Health by Prescribing the Manner in Which Water Liable to Breed Mosquitos Shall Be Cared For Within the Limits of the City of New Orleans." The substance of the first eight sections of the ordinance is given below. We have substituted "prohibits," at the beginning of most of the sections, for "That it shall be unlawful to set up, have, keep or maintain on any premises in the City of New Orleans," and have made a few other changes for the sake of brevity. The prohibitory clauses are as follows:

(1) Prohibits the construction or maintenance of any cistern, tank or well that is not screened with wire mesh not coarser than 18 wires to the inch, both ways, provided that the inlets and outlets of such cisterns, tanks or wells may be screened in any manner or with any material approved by the Board of Health, that will thoroughly prevent the ingress or egress of mosquitos to and from the water therein contained; provided, however, that no water seal shall be used in screening any such inlets or outlets.

(2) Prohibits on any pond, pool, fountain, trough, urn or water receptacle of any similar character or kind, unless the same is kept constantly covered with kerosene oil from Feb. 1 to Dec. 1, in each year, or be kept constantly stocked with mosquito destroying fish, or covered with the protective netting specified in Sec. 1.

(3) Prohibits between Feb. 1 and Dec. 1 in each and every year to the keeping of water in any can, pitcher, bowl, bottle, tub, bucket, barrel, trough or other receptacle, unless the same be thoroughly emptied, dried or cleansed every five days before being refilled; provided, however, that fire barrels may be maintained on premises, provided that they are properly screened with 18 × 18 wire mesh, but all fire buckets shall be maintained empty.

(4) Prohibits any open well, unless the same be continuously closed or screened as above provided, so as to prevent the ingress or egress of mosquitos to and from the water therein contained and the drawing of water therefrom be operated by pumps.

(5) Prohibits any gutter or drain or roof in or on which water stands after rains, without draining off thoroughly.

(6) Prohibits any open cesspool or privy vault to the liquid contents of which mosquitos have ingress or egress, unless the same be thoroughly covered with petroleum oil every 15 days from Feb. 1 to Dec. 1 in each and every year.

(7) Every lot or square in this city which, in the judgment of the Board of Health, is near enough to the houses of its inhabitants on which water stands in pools or ponds, or which contains excavations or holes or depressions in which water may stand, is hereby declared a menace to public health, and the owner thereof who shall fail, after notice by the City Board of Health and within the time therein prescribed, to fill or drain the same or keep it covered with petroleum oil, shall be deemed guilty of a violation of this ordinance.

(8) Prohibits in any house or hotel water closets furnished with a tank or basin with water seal, unless such tanks or basins be emptied and the water therein renewed at least once in five days, from Feb. 1 to Dec. 1 in each and every year, or be kept during the same period thoroughly covered with kerosene oil.

Four additional sections provide penalties for violations of the prohibitory sections and define the responsibility of owners, agents and tenants of premises, lots, etc. Violators of any section of the ordinance are liable to a fine of not more than $25, or to imprisonment for not more than 30 days, or both, in the discretion of the court of jurisdiction, each day of violation constituting a separate offense. With the exception of Section 5, on roof gutters or drains that permit water to stand, and Section 7, on draining, filling or oiling pools and ponds, all the prohibitory clauses are self-operative. For the excepted clauses, notification from the Board of Health is necessary to make them effective.

The responsibility for screening cisterns, tanks and wells (Secs. 1 and 4), for defective roof gutters and drains (Sec. 5) and for draining, filling or oiling pools and ponds, on notice, is placed on owners or agents of property, except where, without the knowledge of the owner or agent, violations are by tenants or trespassers, in which case the liability falls on the tenant or trespasser. In case premises are vacant, or are occupied jointly by the owner and his tenants or sub-tenants, the owners or agents are also liable for violations of Secs. 2, 3, 6 and 8; and in case of joint occupancy by owner and tenants both owner and tenants are liable for violation of these same clauses.

THE $50,000,000 ROAD IMPROVEMENT LOANS made possible in New York State by the constitutional amendment adopted in November, 1905, will be made in accordance with the following extract from the joint legislative resolution providing for the amendment:

A debt or debts of the state may be authorized by law for the improvement of highways. Such highways shall be determined under general laws, which shall also provide for the equitable apportionment thereof among the counties. The aggregate of the debts authorized by this section shall not at any one time exceed the sum of $50,000,000. The payment of the annual interest on such debt and the creation of a sinking fund of at least 2% per annum to discharge the principal at maturity shall be provided by general laws whose force and effect shall not be diminished during the existence of any debt created thereunder. The Legislature may by general laws require the county or town or both to pay to the sinking fund the proportionate part of the cost of any such highway within the boundaries of such county or town and the proportionate part of the interest thereon, but no county shall at any time for any highway be required to pay more than 0.35 of the cost of such highway, and no town more than 0.15.

Of the 61 counties of the State, only three voted against the amendment (Orleans, Schuyler and Yates), but their combined adverse majority was only 876, compared with a majority of 266,883 in favor of the amendment in the 58 other counties of the State.

THE NEW YORK CANALS had more pleasure craft than freight boats upon them during the 1905 navigation season, according to the report of Superintendent Franchot. Nearly 1,000 permits for the use of the canal were issued to owners of pleasure craft, while the number of freight-carrying boats on the canals has now dwindled to less than 600. Of course the freight boats run the whole season, while many of the pleasure boats make only a single short trip.

MUNICIPAL OWNERSHIP OF THE STREET RAILways of Berlin, Germany, is proposed. The authorities of that city and of eight suburbs, it is said, have decided to buy out the Berlin Street Railway Co. and operate the system as a joint municipal venture.

WOOD BLOCK PAVEMENT ON LOWER BROADway, New York City, or from the City Hall Park to the Battery, is to be laid within a few months. The contract has recently been awarded to the U. S. Wood Preserving Co., of New York City. The blocks will be treated by the creo-resinate process.

BONFIRES ON ASPHALT PAVING in the Borough of Brooklyn, New York City, cause heavy damages every year. Estimates based on recent bills from the paving companies place the cost of repairs at $90,000, but some of these repairs may be chargeable to other causes.

UNDERGROUND MAIN TELEGRAPH LINES between London and Glasgow are being built by the British Post-Office Department. It is expected that they will be in service in March or April, 1906.

A MUNICIPAL FERRY between the Battery (Manhattan) and 39th St. (Brooklyn), New York City, is proposed. A ferry has been operated over this route for many years by private parties, and the city proposes to buy and operate the line. The city recently acquired and now operates the ferry from the Battery to Staten Island.

THE EXPLOSION OF SEPTIC TANK GASES at Saratoga Springs, N. Y., on Jan. 26, blew off the concrete roof of one of the four septic tanks forming part of the sewage works of the village. An illustrated description of these tanks was published in Engineering News of Feb. 2, 1905. The tanks are 51½ × 91½ ft. in plan, and are covered by elliptical groined arches with spans of 11¼ ft., rises of 2½ ft., crown thickness of 6 ins., and depressions of 9 ins. over the piers, drained by 2-in. pipes, leading into the tanks. Each tank had a holding capacity of 250,000 gallons.

THE PRODUCTION OF PIG IRON in 1905 was 22,992,380 gross tons, according to statistics collected by the American Iron and Steel Association. This is the greatest output of American blast furnaces ever recorded. Classified according to the purposes for which the iron was intended, the figures are as follows:

Class.	Tons.	Per cent.
Foundry and forge	5,837,174	25.4
Bessemer	12,407,116	54.0
Basic	4,105,179	17.9
Charcoal	352,928	1.5
Spiegel and ferro-mang.	289,983	1.2
Total	22,992,380	100.

The largest previous year's output was recorded in 1903 and was 18,009,252 gross tons.

PERSONALS.

Mr. Medard Breault, a contractor, has been appointed Water Commissioner of Troy, N. Y.

Mr. W. A. Morey, Chief Engineer of Bridges and Buildings, with the Denver & Rio Grande R. R. Co., has resigned.

Mr. H. E. Martin has been appointed superintendent of Buildings of the Denver, Enid & Gulf R. R. Co. with headquarters at Enid, Okla.

Mr. J. M. Callow, President of the General Engineering Co., Salt Lake City, Utah, is now in Europe in the interests of the new company.

Mr. M. O'Dowd has been appointed Chief Tie and Timber Inspector of the St. Louis & San Francisco Ry., with headquarters at Springfield, Mo.

Mr. Joseph P. Gray was recently elected President of the Boston Manufacturers Mutual Fire Insurance Co., of Boston, Mass., to succeed the late Edward Atkinson.

Mr. E. K. Woodward, Division Engineer of Maintenance of Way of the Wabash Ry., has been appointed Principal Assistant Engineer, with offices at St. Louis, Mo.

Mr. J. B. Yohe, heretofore General Superintendent of the Pittsburg & Lake Erie R. R., has been appointed General Manager of that road, with headquarters at Pittsburg, Pa.

Mr. George W. Bradshaw has been appointed Assistant Supervisor of Signals of the Middle Division of the Pennsylvania R. R. Co., at Altoona, Pa., replacing Mr. W. N. Spangler, transferred.

Mr. J. F. Deimling has been appointed Chief Engineer of the Pere Marquette Ry., with offices at Detroit, Mich. He is succeeded by Mr. W. J. Long as Division Engineer at Grand Rapids, Mich.

Mr. George S. Tibbits, City Engineer of Oneida, N. Y., and his Assistant, Mr. W. N. Peckham, have formed a partnership and opened an office on Main St., in that city, for the practice of civil engineering.

Mr. Charles A. Budd, of the Bridge and Building Department of the Chicago, Milwaukee & St. Paul Ry., has been transferred to Seattle, Wash., as Bridge Engineer of the new Pacific coast extension of that road.

Mr. James A. Milne, who has for a number of years been Comptroller of the Allis-Chalmers Co., of Milwaukee, has been appointed General Manager of the Allis-Chalmers-Bullock Co., Limited, of Montreal, Canada.

Mr. Gardner T. Williams, M. Am. Inst. M. E., for many years General Manager of the De Beers Mining Co., in South Africa, has retired from that position and will reside in Washington, D. C. He will be succeeded by his son, Alpheus F. Williams.

Mr. H. I. Orwig, for several years engineer in charge of surveys of the Land Department of the Chicago & Northwestern Ry., has resigned to take up private practice as an engineer and surveyor, and has opened offices at 112 Clark St., Chicago.

Mr. W. L. Sisson, who was recently appointed assistant to the Harbor Engineer of Baltimore, has resigned his position to go to the Philippines. Mr. William Atlee, employed for the last three years by the Western Maryland R. R. Co., has been appointed in his place.

Mr. William D. Cantillon, General Superintendent of the Chicago & Northwestern Ry., has been advanced to the position of Assistant General Manager, succeeding Mr. R. H. Aishton, who becomes General Manager. Mr. Cantillon has been with this company since 1878, starting in as a brakeman.

Mr. L. F. Bower, heretofore Manager of the Allis-Chalmers Co.'s electrical works at Cincinnati, O., has been appointed Comptroller of this company. Mr. Bower was graduated from Wesleyan University in 1879 and for some time he was Secretary and Treasurer of the Dickson Manufacturing Co., at Scranton, Pa. He subceeds Mr. J. A. Milne.

Mr. J. F. Deimling, heretofore Division Engineer Maintenance of Way of the Pere Marquette R. R. Co., at Grand Rapids, Mich., has been appointed Chief Engineer, with headquarters at Detroit, Mich. Mr. J. Tuthill has been appointed Engineer of Bridges and Buildings, with office at Detroit, Mich. Mr. Tuthill heretofore has been Engineer of Bridges.

Mr. Geo. W. Harris has opened an office as a Consulting Mining Engineer at Beckley, Va., and will make a specialty of coal and coke development and the purchase, sale and examination of coal and timber lands. Mr. Harris has had 15 years' experience in coal mining engineering and was formerly on the editorial staff of the "Mineral Industry."

Mr. Charles C. Huestis, Assoc. M. Am. Soc. C. E., who for the past five years has been General Manager of The T. H. Riddle Construction Co., of New Brunswick, N. J., has been elected General Manager of the Essex Construction Co., lately organized under the laws of New York State to do a general engineering, contracting business, with headquarters in the Prudential Building, Buffalo, N. Y.

Mr. A. H. Horton, has been appointed District Hydrographer in the Chicago office, to succeed Mr. F. W. Hanna, who has been transferred to Washington to take charge of the technical section in the U. S. Reclamation Service office. Mr. Horton's district includes the following states: Ohio, Indiana, Illinois, Kentucky, Missouri, Iowa, Wisconsin, Minnesota, and the northern peninsula of Michigan.

A new hydrographic district has been organized in the U. S. Geological Survey, to include the states of North Dakota and Montana, and that portion of Wyoming including the gaging stations in the Bighorn Basin. Mr. H. N. Morse, of the Washington office, has been appointed District Hydrographer under the general supervision of H. N. Savage, Supervising Engineer, with headquarters at Huntley, Mont.

Mr. R. C. Newhouse, who for the past year has been associated with the crushing and cement machinery selling organization of the Allis-Chalmers Company with headquarters at the general offices, Milwaukee, has been transferred to the Cincinnati sales offices, located in the First National Bank Building, Cincinnati, where he will continue to promote the sale of Allis-Shalmers rock crushing and cement making machinery.

Mr. Waldo H. Marshall was elected President of the American Locomotive Co. at a special meeting of the Board of Directors held Feb. 5. Mr. Marshall resigns the office of General Manager of the Lake Shore & Michigan Southern Ry., which he has held since July, 1903, to accept his new position. He entered railway service in May, 1897, as Assistant Superintendent of Motive Power, Chicago & Northwestern Ry. In June, 1899, he went to the Lake Shore & Michigan Southern Ry., where he occupied successively the offices of Superintendent of Motive Power, General Superintendent and since July 1, 1903, General Manager. Mr. Marshall, though having an unusually successful record in railway managerial positions is perhaps best known to engineers as an expert through long study and practical experience in locomotive design and operation.

Obituary.

Herman Poole, M. Am. Soc. M. E., a mining engineer and metallurgist, of New York City, died Feb. 7.

C. Napier Bell, M. I. C. E., an Australian civil and harbor engineer of prominence, died at Derby, Tasmania, on Jan. 3.

O. C. Ellison, one of the founders of the National Irrigation Congress, died on Feb. 8, at Guaymas, State of Sonora, Mexico.

Per Brynn, Chief Draftsman of the Carnegie Steel Co., at Pittsburg, died in New York City on Feb. 10. Mr. Brynn was married about two weeks ago.

George D. MacMillan, of La Crosse, Wis., President of the La Crosse Gas and Electric Company, died on Feb. 12, of uraemic poisoning. He was 61 years old.

Wm. F. Nisbet, at one time Secretary of the Architectural Iron Works, of New York City, and later President of the St. Joseph & St. Louis R. R., died Feb. 5 in New York City.

John W. Thomas, President of the Nashville, Chattanooga & St. Louis Railway, died in Nashville, Tenn., on Feb. 12. He was born Aug. 24, 1830, at Nashville. He entered the railroad business in 1858.

Joseph H. Linton, a civil engineer, who was awaiting the confirmation of his appointment as an engineer on the Panama Canal, was recently killed by a falling boulder, while acting as a foreman of a construction crew on the Oregon R. R. & Navigation Co., along the Snake River.

John O'Connor, a contractor, of Oswego, N. Y., and Pittsburg, Pa., recently died at Palm Beach, Fla. Mr. O'Connor was a member of the firm of Drake & Stratton, of Pittsburg, and had been actively identified with the building of several Southern railroads and the construction of the Washington, D. C., reservoir and the Jerome Park reservoir, at New York, N. Y.

Commander George W. Mentz, Inspector of Ordnance and acting Captain of the League Island Navy Yard, died at Philadelphia on Feb. 11 of apoplexy. Known as one of the most distinguished ordnance officers in the navy, Commander Mentz was assigned to the League Island station last July. He was appointed to the Naval Academy from Newark, N. J., in September, 1866. He was a member of the Coast Survey, 1879-83; at Annapolis, July 20, 1897, until appointed Lieutenant-Commander in March, 1899, occupying that position until the time of his appointment to League Island. His wife was Florence M., daughter of Gen. F. F. Millen. She and one son survive him.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Feb. 21. Annual meeting at South Bethlehem, Pa. Sec'y, R. W. Raymond, 99 John St., New York City.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
Mar. 20. Annual meeting at Chicago, Ill. Sec'y, L. C. Fritch, 1562 Monadnock Blk., Chicago, Ill.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.—At the February meeting of this society, held at Seattle, Wash., on the evening of Feb. 3 a paper, entitled "Recent Development in Electrical Engineering," was read by Prof. C. E. Magnusson, of the University of Washington. The paper dealt largely with the advantages of single-phase alternating current for suburban lines carrying heavy traffic. The paper was discussed by Messrs. E. G. Allen, H. D. Hanford, C. A. Whipple and W. S. Wheeler. Secy., A. H. Dimock.

ILLUMINATING ENGINEERING SOCIETY.—This new society, whose formation was noted in these columns a few weeks ago, held a meeting at the Hotel Astor, New York City, on the evening of Feb. 13. Mr. L. B. Marks, President, read an address in which he discussed the field which lies before the society, the magnitude of the interests involved, and related topics. An interesting discussion followed, in which a dozen or more persons, representing all phases of illumination work, took part. Most interesting, perhaps, was the remarks of Prof. C. F. Chandler, who reviewed some of the history of artificial illumination, beginning with the supremacy of whale oil, passing through the days of camphine, "burning fluid," and coal oil, to the discovery of petroleum, followed after fifteen years by the invention of incandescent lighting. The society will hold its next meeting on March 13. It is expected that papers will be presented on the subjects: "The Inverted-Mantle Burner," "Flaming Arc Lamps," "Illumination from the Architect's Standpoint." Secy., E. L. Elliott, 25 Broad St., New York.

LEAGUE OF MICHIGAN MUNICIPALITIES.—The eighth annual convention of the League of Michigan Municipalities will be held at Grand Rapids, Mich., on Feb. 20 to 22, 1906. Hotel headquarters will be at The Livingston, and meetings are to be held in the St. Cecilia Auditorium. Seven meetings will be held, beginning with a reception and an illustrated address at 8 p. m., Tuesday, and continuing morning, afternoon and evening of the two following days. The following papers are to be read: "American Municipal Progress, Public Service," with stereopticon views, by Prof. Chas. Lueblin, of the University of Chicago; Presidential Address, by Mayor E. F. Sweet, of Grand Rapids; "Municipal Progress With and Without Brakes," by Alderman D. E. Heineman, of Detroit; "How to Swing the Ax," by S. A. Freshney, Commissioner of Public Works of Grand Rapids; "Good Roads," by Mayor W. W. Todd, of Jackson; "Hints on Asphalt Paving and Repairs," by C. A. Proctor, Asphalt Inspector, Detroit; "The Municipalities' Interest in Constitutional Amendments," by Mayor G. P. Codd, of Detroit; "The Revision of the State Constitution," by Representative H. T. Heald, of Grand Rapids; "The Municipal League," by Mr. J. F. Bible, of Ionia; "Progress and Association," by Mayor H. Geerlings, of Holland; "Local and Interurban Railroads," by Mayor W. R. Taylor, of Kalamazoo; "The Press and Municipal Progress," by Mr. A. H. Vandenberg, of Grand Rapids; "Conscience in Municipal Affairs," by Mayor Francis Hamilton, of Ann Arbor; "Municipal Ownership of Public Utilities," by Mayor E. F. Dunne, of Chicago, Ill., and Mayor Tom Johnson, of Cleveland, O. On the afternoon of Feb. 21 there will be a conference of city comptrollers, treasurers and clerks, on Uniform Municipal Accounting, preceding the general session of the afternoon. Secy. A. Fairlie, Ann Arbor.

WESTERN SOCIETY OF ENGINEERS.—At [illegible] ing on Feb. 17 Mr. M. O. Leighton, of the U. S. Geological Survey, presented a paper on "High [illegible] Sluicing Gates," referring particularly to [illegible] adopted by the U. S. Reclamation Service for [illegible] velt (Arizona) and Shoshone and Pathfinder [illegible] dams. At most dams a series of large pipes are [illegible], but for these three dams it has been found ne[illegible] to provide openings of unusually large size for slui[illegible] poses, to prevent the silting up of the reservo[illegible]. The gates are placed in tunnels so as to avoid openin[illegible] the dams themselves. There are two gates to ea[illegible] a service gate and an emergency gate, both of th[illegible] ney type. At the Roosevelt dam there are three sets [illegible], for openings 10 × 4½ ft., and the pressure will [illegible] per 100 lbs. per sq. in. against the gates. These g[illegible] will be operated by wire cables from hydraulic cylinde[illegible] working at 600 lbs. pressure, and in order to avoid h[illegible] to excavate a high chamber the piston rod is ma[illegible] telescopic. Gates of the swing or Taintor type may b[illegible] at other dams.

At the meeting of the Electrical Section on Jan. 26 there was a discussion on "The Best Type of Electric Car for City Service." This was opened by Mr. Mason B. Starring, General Manager of the Chicago City Ry., who described the new cars adopted by this company. These cars [illegible] 45 ft. long, seating 44 passengers; they have steel [illegible] panels and double or storm windows, and are heated by electricity. The electrical and other details were described by Mr. Harvey B. Fleming, Superintendent of Maintenance, and Mr. D. A. Faut, Master Mechanic. Following this, Mr. Geo. A. Damon described the central-entrance type of car now in use at Denver. These cars are 41 ft. 6 ins. long, weighing 37,000 lbs. and seating 48 passengers. At each end is a closed compartment, with a wide vestibule between them; in winter only one compartment is heated, as many people prefer simply shelter without the heat. In the rush hours similar cars are hauled as trailers; these weigh 12,300 lbs. The motor cars require 2.5 KW.-hours per car miles, or 3.5 KW.-hours when hauling trailers. The election of officers for the Electrical Section resulted as follows: Chairman, S. G. McMeen; Vice-Chairman, O. E. Osthoff.

At the regular meeting of the Society on Feb. 7 there was presented a paper by Mr. George H. Bremner on "The Areas of Waterways for Railway Culverts and Bridges." This referred to the necessity of careful determination of such areas, in order to avoid an unnecessarily large and costly structure on one hand, or a structure of insufficient capacity on the other hand. The paper dealt particularly with the practice of the Chicago, Burlington & Quincy Ry. Communications describing the practice of other roads were read, from Mr. J. Dun, Chief Engineer of the Atchison, Topeko & Santa Fe Ry., and Mr. Lewis Kingman, Chief Engineer of the Mexican Central Ry. A communication from Mr. John W. Alvord discussed the subject from the point of view of the hydraulic engineer, and showed that in railway work there is a tendency to rely too much upon the universal application of a formula, in spite of the numerous and varying conditions at each watershed. Investigations of run-off, etc., are among the important works in connection with sewerage, drainage and water supply problems, and the railway division engineer is very often not properly equipped for making such investigations.

A written discussion from Mr. L. B. Merriam stated that while a large number of variables enter into the computations, the final formula for use in the field must be reduced to the fewest and simplest terms. On preliminary and location surveys the determinations for waterway need not as a rule be made with extreme nicety, since temporary structures are usually of timber, but these should be of simple size. It devolves upon the engineer of maintenance to finally determine the sizes of the permanent structures. If these engineers would instruct their assistants to measure the flow through culverts during severe storms, the constants for the formulas would become more accurate.

Mr. O. P. Chamberlain remarked that railway practice is to calculate the discharge of flood water at an assumed velocity (usually 10 ft. per second) rather than at the actual maximum flood velocity. As this assumed velocity is much higher than the actual velocity in flat and rolling country, the arches and culverts are smaller and more economical than they would be if designed for flood velocity. Only in streams through rapidly sloping ravines and for large rivers is it necessary to consider the latter velocity. If the embankment is high enough to raise the flood to a head sufficient to discharge through the culvert at 10 ft. per second, the culvert is safe and is more economical than if it had been designed for the mean velocity through an unobstructed drainage basin. The raising of the flood level would be only for a few hours and would rarely be of any consequence. In filling old pile trestles and open culverts the new openings are often too few and too small. Mr. L. E. Cooley gave a long and interesting review of methods and practice in this class of hydraulic investigation.

ENGINEERING LITERATURE

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EDITORIAL.

The Preparation of Drawings and Other Illustrations for Photo-Reproduction.

There is probably no other adjunct to the making of technical literature which is so little understood and so carelessly handled as the preparation of the necessary text illustrations. And yet a great many publications depend for their principal value upon the illustrations which accompany the text matter. It therefore follows that poorly rendered illustrations will detract not only from the appearance, but also from the usefulness, of a book or paper, as compared with illustrations neatly and clearly executed, correctly drawn as to details and legibly lettered.

For the reproduction of line drawings many authors and publishers resort to the so-called "wax engraving process." Here the original, either a tracing, or a blue-print, or pencil sketch on detail paper, is photographed in the desired size upon the sensitized waxed surface of a copper plate. The outlines of the drawing are then scratched through this wax enamel down to the blackened copper backing by means of different sized gravers. The lettering on such a drawing is set up in type and stamped into the softened wax. The finished wax engraving is "electrotyped," the film-like copper covering on the wax mold is backed with type-metal, mounted "type-high," and is then ready for printing.

The wax engraving is considered by numbers of technical men as the very acme of perfection, since the lines print clean and sharp and the lettering is legible. Such illustrations certainly have a smooth and finished appearance, but they are to a large extent routine copies of poor originals, with more or less liability of errors and omissions, as every line must be ruled in by hand and all the lettering must be reproduced by setting type and impressing it in the wax. Since it is easier to get superficially passable results from a poor drawing by means of the wax process than by the processes to be described later, there is perhaps more likelihood that poor material for illustrations will be used for the wax than for the other processes. The clear, even lines and uniform, legible lettering of the wax engraving cover a multitude of sins and give rise to many illustrations which are of little use for purposes of careful study. This is most likely to be true when the illustrations are complex. For simple line drawings and diagrams the wax process has much to commend it, especially where the services of good draftsmen are not available.

When an author or publisher wishes to make sure of a facsimile reduction of as perfect a line drawing as is needed for his purpose, he will have it reproduced by photo-lithography or by photo-engraving on zinc. Photo-lithography is generally employed for making large-sized illustrations for folding sheets and insets, which cannot very well be handled economically by the ordinary printing press. The originals require the same finish as those used for the zinc process. The photographs, reduced to the desired size, are transferred to a polished lithographic stone, which, after being re-etched, is ready to print from in the lithographic press. Original photographs may also be reproduced in this way, giving the same general result as by the more familiar half-tone process, described further on.

A line engraving on zinc is produced by first printing a reversed negative, made from a large original, upon a polished and sensitized zinc plate. When inked by means of a printing roller, the ink adheres to the black lines of the plate, corresponding to those on the original drawing. Powdered resin is then sprinkled over the plate. It adheres to the ink lines, and on being heated it melts and forms a protective coating against the etching solution. This solution is next poured over the plate and is allowed to remain until it eats out enough of the metal between the lines to leave the latter in clear relief. More metal is then removed or "routed" from between the lines by means of a finishing tool. Finally, the zinc plate is mounted upon a wood block and is ready for use in the printing press.

The process thus briefly outlined requires in the way of original drawings pure black lines on a clear white or bluish-white background. The medium upon which to draw may therefore be white paper, tracing paper or transparent vellum. Buff colored paper has sometimes yielded fair results, but its use is not advisable. It must be remembered from the very outset that the drawing is to be made for a certain amount of reduction, generally large, and that consequently it must be made so that when reduced its details will still be recognizable, its lines still separated from each other, and, above all, lettering and descriptive symbols must be readily legible.

The reductions to which drawings are subjected may vary all the way from "one-half" to "nine-tenths"; that is to say, from one-half to one-tenth the original size (linear measure). An easy reduction to work for may be called the "two-thirds" reduction, or to one-third the linear measure of the original. The lines in such a drawing will have to be neither too bold nor too fine, and the lettering may be made of moderate size. As stated above, the draftsman must know from the very outset the rate of reduction and must proceed accordingly, always having in mind, for instance, that for a two-thirds reduction his lines must be three times the width of those on the final proof taken from the finished plate. This rule, however, need not be carried out rigidly, because fairly fine, black lines, having a ridge of ink on top, will always possess a value in photographing, and will consequently be recorded upon the negative. Some draftsmen are in the habit of screwing up the nibs of the ruling pen tightly, so as to produce a fine line. The result is that the ink is squeezed out beneath the points and a gray, very fine line will result, which will either not photograph at all or come out only in spots. Therefore, it is advisable never to try to introduce too fine lines into any drawing, and it is necessary to make sure that all lines are perfectly black.

When working for reduction a drawing should always be presented in its essential details; all unnecessary center-lines, invisible and construction lines, as well as dimensioning, should be omitted. In order to make clear the construction of whatever object may have to be presented, a certain amount of outline shading, very boldly executed, may prove of great value. The shading should be heavy and decisive, the shade-lines being five or six times as heavy as the ordinary outlines. The draftsman must be quite sure in his own mind as to what parts must "stand out," as; also, what portions should be shown as receding, and shade accordingly.

Center-lines should be shown the strength of ordinary outlines. The neatest symbol, and most suggestive perhaps, is the "dash and dot" line, with regular spacing between, showing dashes shorter than is customary at present. Invisible and construction lines should only be employed where clearness demands their use; short dashes will answer very well for that style of lines. Dimension lines in a well executed drawing should be the least prominent of all, and should therefore be shown in very short light dashes or dots, leaving open spaces for the dimensions themselves. In this way the solid outlines of the drawing are not in any way interfered with; the eye takes in at a glance the object itself; all auxiliary lines are thus made of secondary importance.

Additional clearness may at times be gained by introducing a few touches of curved surface shading, where such will aid the understanding of a certain shape, which perhaps is not otherwise made clear by any other view. Such shading, where properly executed, will greatly improve the appearance of a drawing, but is unfortunately often used indiscriminately, and in such cases detracts from the clearness of the illustration. In the style of shading there is a special tendency for the draftsman to use too close a spacing. Where portions of a view are to appear in section, the proper section-lining should conscientiously be used, being quite sure that all such parts are properly designated in this way. Parts shown in elevation should under no circumstances receive any such ruling; a very rigid distinction should always be made between parts in section and parts in elevation by the use of correct sectioning in the former only.

The lettering of a drawing which has been finished up to that point must again be put in with a view of purely supplementing the drawing, and perhaps the accompanying text matter. It should all be placed so that it may be read from the base and the right-hand side of the sheet. A proper distribution of such descriptive matter in the shape of notations, titles and numerals will wonderfully enhance the appearance of a drawing—the reverse also holds good. There should be no attempt to crowd dimensions, reference letters or small notes into their respective spaces where such are too small. Instead, they should be placed boldly outside or opposite, as the case may be, and dotted reference lines used, with arrowheads attached. This rule should be adhered to especially where there is no great amount of lettering used, so that in such a case the outlines of the figures are permitted to stand out clearly and distinctly by themselves. The style of lettering used depends, of course, greatly upon usage and individual preference; but no lettering for reduction work can compare in legibility and rapidity of execution with the so-called one-stroke Gothic lettering, either inclined or vertical. The inclined style can with advantage be used for all purely descriptive matter, dimensions, notations, etc.; the upright lettering will naturally commend itself for sub-captions, reference letters and main divisions, which ought to be emphasized. The so-called "all-cap" lettering requires more time to construct, and is not so readily legible as the "cap-and-lower-case" lettering, which latter style has for those reasons come into almost universal favor. Main titles or captions for any reproduction can cheaply and neatly be set up in type; therefore the construction of such by hand on any drawing for photo-reproduction is nearly always useless and expensive. Underlining of lettering is undesirable, as it tends to distract attention from the outlines of the drawing itself. As the one-stroke lettering is supposed to be drawn in uniform strength of body, a specific mode of procedure becomes necessary—the direction of strokes and their sequence ought to be carefully studied by every draftsman.

The different reductions to which a drawing may have to be subjected require, of course, different sizes of lettering, and well worn pens of different makes can be used to produce just the

requisite strength of body for the letters, with one application for each stroke, for it goes without saying that the strength of the body of the letters must be in accordance with their respective sizes. For lettering on a drawing above a "five-sixths" reduction (i. e., to be reduced to one-sixth its original length), a stiff, red sable brush can be used with advantage. In order to be legible to the average reader, the lettering on any reproduction should not come out smaller than uniformly one millimeter high in the small lower-case letters, such as "a," "e," "m," "n," for instance. The other letters must, of course, show in proportion. Therefore the lettering on an original, which, for example, is to be reduced three-fourths (i. e., one-fourth its present length) must be made in the small lower-case letters mentioned four millimeters high, with strength of body in proportion. A drawing thus lettered up and executed will, of course, stand a much greater reduction and yet show legible and clear; nevertheless, the standards given here have been followed where absolutely good work has been essential. Corrections and erasures should be very carefully made, as the brownish tint so often noticeable on tracing-cloth where erasures have occurred will show on the negative obtained by photographing, and must be attended to separately. Such places can be covered up by painting Chinese white over the spots affected.

Very often the reproductions are overloaded with non-essential details, every center-line being shown, the dimension lines all ruled in solid, and a mass of almost illegible lettering being spread over the whole illustration. The reader of such illustration is put to considerable trouble to interpret the drawing; he has to make his own deductions, read between the lines, as it were, and often gives up the task in disgust. All this is caused by reproducing an unsuitably drawn and lettered illustration, almost useless, at the best; certainly not serving as an ornament to the publication in which it appears.

There is no reason why many original drawings cannot be made so bold, in both lines and letters, that instead of having the originals blue-printed in the ordinary cumbersome way they could simply be photographed down to perhaps one-fourth their length. Portfolios containing such reduced original drawings of the Pittsburg Filtration Works and of the recent improvement of the New York Central R. R. appear exceedingly handy and serviceable, and are certainly far superior to the unwieldy and at times almost unmanageable roll of blue-prints, which otherwise have to be handled.

It may be mentioned as a curiosity that sometimes pencil-drawings on tracing paper have given good results in reproduction; the pencil lines were evidently black enough to possess some value in the exposure.

Occasionally it becomes necessary to reproduce an illustration taken directly from some book, pamphlet or periodical. Such a reproduction can, of course, not be reduced very much, and from the outset of such operation it must be determined just how much reduction it can "stand." The outlines of the illustration to be reproduced can with some care be retouched where ragged or broken. The principal part to be amended, though, on such a sheet is the lettering, which as a rule is poorly done and much too small. Such portions of the lettering as are essential can be pasted over with slips of white paper and the parts re-lettered to the right size upon the paper; the portions not wanted may be obliterated by simply painting over with Chinese white. The dimension lines, which generally were drawn as solid lines, can be cut up with a brush or a fine pen dipped into a solution of Chinese white, so as to produce dotted lines to designate dimensions. The center lines, likewise, can be cut up into regularly spaced, small dots and dashes; the invisible or construction lines can either be painted out altogether or similarly treated. Where outline shading is absent on reproductions, such shading may sometimes be added, if the paper possesses a fairly good surface. Such a remodeled drawing shows up very well in the proper reduction, and can be made fully as serviceable for purposes of study as a well-executed original drawing.

The principles of the so-called "half-tone process" are similar to those governing the making of line-engravings, with the exception that the original, consisting either of wash-drawing or a photograph, is photographed through a screen. The impression recorded on the sensitized plate thereby is a number of opaque dots of varying size, the white sections of the original assuming the largest size, the dots growing smaller in the darker portion until they are completely lost in the solid blacks. The effect is a picture in dots, the varying shades and tints being depicted by various sized dots.

The impression from the reversed negative is taken upon a highly polished, sensitized copper plate, which, after repeated etchings, is ready for the wood mounting. The finishing of such a plate consists in local re-etching, a procedure which will diminish the size of the dots in places, making them print lighter in the finished picture. At times the dark or black portions may have to be "polished" in, the fine white dots in such places thereby being obliterated, so that these portions will print perfectly black. Where repeated local re-etching fails to do justice to the high lights shown in the original, such parts may boldly be engraved out by a skillful finisher, so that they may print absolutely clear white.

If a highly finished picture is wanted, exhibiting high lights and deep shadows, or where the judgment of the finisher is not exactly trusted, resort must be had to retouching the original photograph. On the ordinary brown or sepia prints the high lights are painted in with pure Chinese white, or the same mixed with vermillion, so as to somewhat match the tone of the photograph. Deep shadows are produced by lamp-black with a trifle of vermillion added. Solid blacks can be effected by the use of India ink. The purpose arrived at in all cases is, of course, to somewhat exaggerate the contrasts, as the interposition of the screen in photographing the original will have a tendency to reduce values and more or less flatten the tints. At times the contours of an object shown may be so shadowy against the background that a little outlining in a light neutral color may be all that is required. Such outline may sometimes be done effectively in a slightly lighter color, where dark surfaces adjoin. Nowadays some beautiful work is being done by professional retouchers with the aid of the air-brush, which is worked by compressed air. The illustrations for modern trade catalogues, with their magnificent cloud backgrounds, are nearly all prepared by means of the air-brush.

Most photographs will be found to have a glazed or polished surface, which will not receive water colors readily. In such cases the surface can be gone over gently with an ordinary artist's rubber, taking care not to cause any streaks or scratches. At times some rubbing with the tip of the finger to which a little powdered pumice has been applied, may be effective upon refractory portions.

Retouching of "Velox" prints can be done with neutral colors without any admixture of vermillion or brown. Here the black generally needs reinforcing. On dull Velox prints some good work can sometimes be done with an ordinary H. B. drawing pencil.

As occasionally reproductions from line-engraving can effectively be "doctored up," so also proofs from half-tones may be prepared for a new reproduction. The proofs cut from magazines or trade-papers can be mounted, and where judiciously retouched will give very good results The only difficulty which engravers generally encounter in this class of work is the matching of their screen upon the screen which the original contains. If this cannot be done correctly a peculiarly mottled effect upon the surface of the new plate will result.

At times it may become desirable, for one purpose or another, to entirely redraw an unsatisfactory small illustration, or to make a pen-and-ink sketch from a photograph. In such a case a "silver-print" enlargement is made from the original; the silver-print is mounted and is ready for drawing. The light-brown tint of such a print permits of distinguishing the lines drawn upon it; only the absolutely necessary outlines should be drawn upon the print with waterproof ink; parts which ought to be amended or points to be preserved and nevertheless to be modified in execution can be drawn in pencil. After this has been done the print is bleached in an enameled pan with a bichloride of mercury solution, the application of which will cause the photographic color to disappear, leaving only the pure white paper, with black ink, or occasional pencil outlines upon it. After rinsing in clean water the print is ready to continue with when dry. Such drawing can be finished in the style advocated above; a pen-and-ink sketch can be executed boldly in black and white, following the technic observed in an etching, or a newspaper illustration. Small mistakes can be rectified by painting over with Chinese white. A good rule to follow is to draw general outlines on such prints sufficiently heavy, as the reflection of the pure white background upon the black lines will have a tendency to make them appear too narrow in photographing. As a rule, all pen-and-ink portraits for periodicals are made in this manner. A drawing upon a bleached silver-print should never be exposed very long to bright light, as otherwise the original brownish tint of the print will begin to reappear, a matter which would make a good photo-reproduction of the drawing impossible.

BULLETINS, U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 6 x 9 ins.

No. 243: Cement Materials and Industry of the United States. By Edwin C. Eckel. Pp. 395; 15 plates and one text figure.

No. 247: The Fairhaven Gold Placers, Seward Peninsula, Alaska. By Fred H. Moffitt. Pp. 85; 14 plates, 2 text figures and two folding maps in pocket.

No. 251: The Gold Placers of the Fortymile, Birch Creek and Fairbanks Regions, Alaska. By Louis M. Prindle. Pp. 89; 16 plates (one in pocket).

No. 265: Geology of the Boulder District, Colorado. By N. M. Fennemon. Pp. 101; 5 plates and 10 figures in the text.

No. 267: The Copper Deposits of Missouri. By H. Foster Bain and E. O. Ulrich. Pp. 52; one plate and two text figures.

The largest of these four bulletins is a very useful and long-needed summary by states of the location and character of the cement material deposits of the United States. An introductory chapter outlines concisely the materials used and the processes employed in cement manufacture. This is followed by chapters or sections giving for each state the general geology of the deposits of clay, shale, limestone and other cement materials and describing the physical and chemical characteristics and the extent and availability of these deposits for cement manufacture. There is also for each state a summary of the industry, with brief descriptions of plants, and a bibliography of the books, papers and reports in print that bear on the subject.

The two bulletins relating to Alaskan gold placer deposits contain the information secured in reconnaissances of the several fields named that were made in 1903 by the forces of the U. S. Geological Survey. In both reports the object has been to present chiefly such data as were of most value to the placer miner and prospector, relegating the more purely geological questions to secondary position.

The discovery of petroleum "supposedly in paying quantities," is the reason given for the survey and studies, begun in 1902, reported in Bulletin 265. The area included embraces 144 sq. miles, with the city of Boulder near its center.

The bulletin on the Missouri copper deposits is the result of a special investigation undertaken during 1904 by the U. S. Geological Survey through the gentleman named. It contains a summary of all the available information regarding the copper deposits of Missouri.

CANADIAN ELECTRICAL ASSOCIATION.—Proceedings of the Fifteenth Convention, Held in the City of Montreal June 21, 22 and 23, 1905. (C. H. Mortimer, Secy., "Electrical News," Toronto, Ont.) Paper; 9 x 13¾ ins.; pp. 47; illustrated.

This report reprints in full the papers and discussions presented at this convention. The papers were of a widely divergent character, but treating electrical machines and distribution from an economical standpoint to a great extent.

Ore Deposits of the World.

Reviewed by N. S. Shaler.*

THE NATURE OF ORE DEPOSITS.—By Dr. Richard Beck, Professor of Geology and Economic Geology, Freiberg Mining Academy. Translated and Revised by Walter Harvey Weed, E. M.; M. Inst. Min. Eng. (England); M. Am. Inst. M. E.; Geologist, U. S. Geological Survey. In two volumes. New York and London: The Engineering and Mining Journal. Cloth; 6¼ x 9½ ins.; pp. 685; 272 figures in the text, and one folding map. $8.

The ancient mining school of Freiberg, in Saxony, has been remarkably fruitful in works helpful alike to the science of geology and to the art of mining. It is indeed hardly too much to say that it has done more for the development of the theory and practice of applied geology than any other center of learning. To it we owe Werner, who, though his views were mostly errors, did more than any other geologist to stimulate inquiry; Von Cotta, who gave direction to the modern study of ore deposits, as well as a host of less famous men to whom is due much of the great and wide-ranging knowledge which now guides those who seek the resources of the under earth.

The reason why the mining school of Saxony has been so effective is not only a matter of general interest, but it also serves in a measure to account for the peculiar value of the work of Dr. Beck. As is well known, the institution was founded and has been maintained for centuries in very intimate relations with the mines of the Erzgebirge district, which lie by its doors. The lodes there exploited are very instructive in their character, and have been extensively developed under the intelligent control of managers who have been educated in the school and of men of lower grade who have ever been in sympathy with inquiry. Thus the teachings of the mines and the laboratory have been united in a manner that is impossible under other conditions. Other mining academies in other German states have had similar opportunities for combining theoretical and practical studies, but none have been in like measure successful. It is a matter of deep regret to all who are interested in earth science that the ore deposits of the Freiberg district are now so near extinction that mining work is there dwindling and is likely soon to cease, so that this peculiar opportunity is soon to pass away.

Dr. Beck's "Nature of Ore Deposits" has that temper which has marked the Freiberg work for a century, and which took shape in the like work of his predecessor, Von Cotta, and the many successive scholars of that school. It is the better for this continual growth. The Erzgebirge mines, by no means of the richest, are classic localities, in that they have, as above noted, been worked for centuries under inquiring and recording masters. Although this last essay is by no means hampered by excessive reference to this local experience, those who know the Freiberg motive will readily discern the fact that the under earth of the wide world is looked at in the light of Saxon experience—good and far-reaching experience it has been—mightily helpful in the world's work.

The aim of this treatise is to give a compendium of what is known as to the origin and distribution of all those deposits which afford important metallic elements, with a measure of attention to each in some proportion to its economical importance, and by the means of a systematic classification of the occurrences.

The plan does not by any means include all earth materials valuable in the arts. The somewhat arbitrary limitation to the so-called metalliferous ores excludes such substances as the sources of potash, soda, thorium, etc.; even bauxite and other actual or possible sources of aluminum have no mention, though they are as much ores of a valuable metal as are those of nickel or of cobalt. This is, perhaps, the gravest defect of the admirable Freiberg quality of the work. It is in another way tied to the good, though very ancient, tradition: it all fundamentally rests on a classification of ore deposits which assumes that any given mass may be brought into a categoric place under a name which will indicate how it was formed. This artificial, essentially unnatural division of the products of mine and quarry, and this devotion to the categoric method of exposition, even where the arrangement of the matter is not helpful to the presentation, is a part of the store that the Saxon school has sent down to us: it is involved with so much that is good that men hesitate to depart from the tradition. It is manifestly unreasonable to treat metalliferous deposits and, as above noted, not even all of them, and leave clays, phosphates, coals, etc., without mention; so, too, it is vexing to find all considerations as to the geographical distribution of ore deposits sacrificed to an ideal of classification.

*Dean of the Lawrence Scientific School, Harvard University, Cambridge, Mass.

Coming to the matter of this work, it may summarily be said that within its limits it is almost beyond praise. What is essential of all the important metalliferous ore deposits of the world is briefly, yet clearly, set forth, and this with a surprising evenness of presentation. The author has an admirable capacity for using the work of others, so that what he has seen and what he has only read about appear as on the same plane. The present writer knows of no other treatise dealing with as varied and wide-ranging features which approaches it in its accuracy and sufficiency. Testing it from a dozen instances of description of localities about the world which the author had evidently never seen, the amount of error seems to be remarkably small. Of the tens of thousands of interesting ore lodes exposed in existing mines only a few hundred could be chosen for illustration, but this choice is so well made that within the assigned limits there are practically no important features left without some measure of notice.

Seeking for features in the book which may be criticized, it may be suggested that the author has not given quite enough consideration to the theory of downward concentration of ores, and in general to the movement of waters in the earth due to gravitation. The index shows but two references to the work of Van Hise; and the action of decaying organic matter in the soil layer in charging the descending rainwater with CO^2, with its manifest effects on ore deposits, as, for instance, on siderites, appears not to be considered.

Here and there are found slips and awkwardnesses of statement which, while of no great importance, deserve correction. Thus, on page 113 is the statement that "a lode may be only ten feet wide or it may be a hundred or more." The apparent implication that there are no lodes less than *ten* feet wide is likely to puzzle the novice. Again, on page 66, in a footnote description of granulite, is the curious statement that it is "not a granite as understood in French." This is a puzzle for the uninitiated, as a number of other like slips which should be cleared away in the next edition. Both those above noted seem to be additions made by the translator.

Although this work is essentially descriptive, there is much admirable, though brief, discussion of the more important general problems of ore deposits and of the main theories to account for their formation; of these but two can be noted here, that concerning the direction of the movement of the waters concerned in the laying down of the ores, and that concerning the extent to which the detrital gold of residual deposits is subjected to solution and redeposition. As to the first of these considerable questions, the author sums up the problem with the statement "that the original formation of most ore lodes is due *to thermal water rising from great depths*." While most geologists are likely to agree with him, many are disposed to assign more value than he does to lateral secretion, for which hypothesis there exists very many instances showing evidence—indeed, we may say positive proof. As regards the solution and redeposition of placer gold, the author shows his admirable—we may, indeed, say marvelous—knowledge of authorities by his reference to the little-known observations of Oscar M. Lieber (here given as O. Lieber) and to the generally overlooked work of Cosmo Newberry. His conclusion is given in the words of Posepny: "That by far the larger part of the detrital gold became liberated by the mechanical destruction of older deposits and was mechanically deposited, but that, on the other hand, a segregation from solutions undoubtedly occurs, though it plays but a subordinate part."

While it must be granted that in the process of erosion of gold-bearing rocks under peculiar and little-understood conditions gold may pass into solution and be redeposited, the reviewer, who has had unusual opportunities for the examination of placers, is confident that the process has practically no importance in accumulating their contents of the metal. The nodular or warty surface of gold nuggets advanced as proof of deposition is rather evidence of solvent action. As for the absence of quartz, it is so commonly present and the fragments of it are so generally angular that they must be taken as indicating the vein origin of the masses. Moreover, the invariable fact that the number and size of the bits of gold in a placer diminish regularly from the evident source of the deposits in the same order as the fragments of other rocks shows that the nuggets were shaped in transportation and not aggregated from solution.

The work of the translator in his emendations as well as his renderings from the German is generally excellent; a comparison with the original shows that the book has distinctly gained in its English form. The additions have been made with care; it is to be regretted that for the use of the American reader they have not been made even more extensive, yet they serve well to make the work fit for American needs.

While Dr. Beck's work is designed for the use of mining engineers, and is for them indispensable, it may be commended to all those who desire to know something of that vast tangle of structures and actions beneath the surface of the earth. It may be commended as a corrective of that commonplace view of the depths which conceives them to consist above of slightly varied dirt and below of somewhat more diversified rock. The reader will soon come to see that it is the overground which is the relatively unvaried, while the under earth is the seat of an infinite variety of physical and chemical conditions.

The book is clearly printed. The illustrations, though simple, sometimes a bit rude, are sufficient, though the German lettering, being retained, may puzzle those who are so unfortunate as not to have some knowledge of the language which is preeminently that of mining literature. The only serious criticisms of the shape of the work is the excessively heavy paper, which makes it a task to hold up a volume for an hour's reading, and the division of the volumes, which is made in the middle of a chapter, a new-fangled arrangement irritating to those who like to see good books in good old forms.

About the best that can be said of a book is that it suggests a better. Here the suggestion is that applied geology is now at the stage of its development when there is need of having its body of fact presented in an encyclopedic manner, with due attention at once to the structure of deposits and to their grouping in geographic areas. The miner's art is already so important that there is place and need for such a work, which may go far to help science as well as to better industries.

THE SCIENCE YEAR-BOOK.—With Astronomical, Physical and Chemical Tables, Summaries of Progress in Science, Directory and Diary. For 1906 (Second Year of Issue). Edited by Major B. F. S. Baden-Powell, late Scots Guards, F. R. A. S., President Aeronautical Society; Author of "War in Practice," etc. London, Eng.: King, Sell & Olding, Ltd., 27 Chancery Lane, W. C. Cloth; 6 x 9 ins.; pp. 208 + 365; illustrated. 5 shillings, net; American price, $2. (Any page separately, in England, for one penny.)

Of the 16 brief signed reviews of the progress of science in 1905 the one on Engineering is by Prof. J. D. Cormack, Assoc. M. Inst. C. E. The list of American Learned Societies omits the American Society of Mechanical Engineers, but gives the Civil, Electrical and Mining Engineers. As a whole, the combined Year-Book and Diary is a unique production, designed more particularly, of course, for use in Great Britain.

Warm Water Supply and Baths.

Reviewed by Wm. Paul Gerhard.*

WARMWASSERBEREITUNGSANLAGEN UND BADEEINRICHTUNGEN.—Guide to the Calculation and Design of Water Heating and Distributing Systems of Public and Private Baths. Prepared for Engineers, Architects and Contractors. By Holger Roose. Munich and Berlin, Germany: R. Oldenburg. Cloth; 5½ × 8½ ins.; pp. 289; 87 figures in the text. 7 marks; American price, $2.80.

This book, as its full title implies, is intended as a handbook for the guidance of engineers, architects, builders and contracting firms who have to do with the calculating, designing and installing of hot water supply apparatus. All those who have had to do with the fitting up of such apparatus in buildings have felt for a long time the need of a sound, reliable and practicable text book on the subject. The author, who is a practising engineer and who has gained a large and varied experience in the offices of several large installation firms, has endeavored to supply this information, at least for German readers.

We have in American engineering literature no single book devoted entirely to this subject, though a large mass of useful material may be found scattered in the various technical and trade papers. Unfortunately, the book before us describes German conditions, apparatus and practice, which differ widely from our own. It cannot, therefore, be said that this book, even if translated into English, would fill the gap.

The most readable chapter and the one from which some useful information suitable for our own conditions may be gleaned is the first or introductory chapter, in which the author discusses the different forms of baths, their advantages and disadvantages, and their requirements as regards hot water. As might be expected in a German book, particular attention is paid to the shower or rain bath, which, as the readers of Engineering News well know, had its origin in Germany, and which has there reached a high degree of popularity, not only for people's or public baths, but also for baths in schools, prisons, military barracks and manufacturing establishments.

Numerous bathing appliances are illustrated and plans showing different arrangements for the bath compartments are given.

While in Germany public bathhouses and institutions are fitted up with bathing conveniences in a very satisfactory manner, not much attention has been paid, so far, to the provision of bathing facilities in private dwellings. Bathrooms which here in America are found even in the smallest dwelling, are on the Continent reserved for the mansions of well-to-do people, hence warm water installations are usually entirely lacking. The author points out the many advantages of baths for private houses and suggests, where space is scant, to provide a bathroom in the attic or even in the cellar! For the comfort and well-being of servants he mentions the installment of a bathtub in the kitchen—under the kitchen table or under the sink, in order to economize space!

On another page we are told that where, in the case of apartment houses, the landlord pays the annual water tax, he often objects to too frequent bathing by the tenants because of the increased water consumption for which he pays! It is, in all seriousness, suggested that in drawing up a rental agreement the number of weekly baths which a family may take should be mentioned in the lease! And where there is only one bathroom for all tenants it is suggested that to each family be assigned one day of the week for bathing, much as here the use of the general apartment-house laundry is divided.

The author's discussion of the warm water supply for swimming pools contains some valuable suggestions and hints; the same applies to the data given for douches, showers and tubs.

The second chapter gives a systematic enumeration of the different systems for the heating of water. These are subsequently discussed quite in detail, and explained with the aid of diagrams and illustrations. Some of the methods outlined are not, however, suitable for American conditions. Too much space is devoted to the old-fashioned European method of heating the bath water by providing a circulating bath boiler placed in the bathroom and connected by piping with the tub. It requires at least one hour to warm the water for a bath. We had really supposed that such impracticable appliances had long ago been superseded by the better English and American methods. Further on in the book, however, the improved means for heating water from the kitchen range fire, from hot water heaters, gas heaters, and also by means of closed boilers containing coils for the circulation of live or exhaust steam, are treated of quite in detail.

A theoretical chapter follows, dealing with the amount of heat units required for the heating of water, with the storage of hot water, the mixing appliances for hot and cold water, the Gegenstrom apparatus, the automatic control of the temperature of hot water, the use of circulation pipes and similar subjects. The next chapter treats of the piping and fittings used, the joints, expansion loops, non-conducting covering, protection of pipe lines against frost, and the testing of pipe systems. The last chapter is a theoretical one giving rules and formulae for the necessary calculations of heating surfaces, hot water tanks and pipe dimensions.

While the book cannot be recommended as one suited to American methods and conditions, it is a praiseworthy attempt to collect and present the information which German engineers require in the design and construction of hot water supply apparatus. The typography of the book is excellent and the price is reasonable.

*Consulting Engineer for Sanitary Works, 33 Union Square, New York City.

THE OYSTER.—A Popular Summary of a Scientific Study. By William K. Brooks, Ph. D., LL. D., Henry Walters Professor of Zoology in the Johns Hopkins University. Second and Revised Edition. Baltimore, Md.: The Johns Hopkins Press. Cloth; 5½ × 8¼ ins.; pp. 225; 16 plates and seven text illustrations. $1.

The now well-known relations between the oyster, sewage disposal and typhoid fever render the new edition of this book of no little possible service to engineers. Written originally in 1890 and founded on studies begun at Johns Hopkins at least as far back as 1878, the book was put forth

in the hope that it might help to bring about a practical and judicious system of oyster farming in Maryland, and the development and improvement of the natural resources of our waters, by an account of the way in which the structure and habits of the oyster fit it for cultivation as a submarine agricultural product.

The present edition is changed in minor points only, except for the addition of a few pages on "the peculiar fitness" of the oyster, structurally, for gathering up the germs of cholera and ty[phoid] fever and transmitting them to man, since the in[creased] clear ideas upon this subject increases with [the growth] of the cities and towns upon the shores of [Chesa]peake] Bay and its tributaries, and with th[e increasing] danger of the pollution of the oyster area by [sewage].

What is said about oysters and typho[id] applies equally to other oyster-producing sect[ions] than Maryland. The non-technical descriptio[n of] the structure, life history, propagation and [plant]ing of oysters given in this book mi[ght be] of service to any engineer called upon to [advise a] city as to sewage disposal where oys[ters] are involved. In addition, the book is of [great] interest as a contribution to both natural and industrial history.

STEAM BOILERS.—Their History and Development. By H. H. P. Powles, Assoc. M. Inst. C. E., M. [Inst.] M. E. London, Eng.: Archibald Constable & Co., Ltd. Philadelphia, Pa.: J. B. Lippincott Co. Cloth; 7½ × 11 ins.; pp. 336; 16 plates and 180 text illustrations. $6.50.

This book is more valuable as a historical work than as a contribution to technical literature. The author begins with the spherical boiler made by Hero of Alexandria about 150 B. C., and devotes the first 100 pages (about one-third of the book) to the work of the old-time engineers in boiler design, confining his review, however, almost wholly to the work of English inventors. He then devotes a chapter of 22 pages to "Plain Cylindrical Cornish and Lancashire Boilers," and one of equal length to "Locomotive Boilers." Then follow chapters on marine, vertical, sectional and fire engine boilers, three chapters on water-tube boilers, one on motor-car boilers, and, finally, two in which a brief comparison is made of the various types and a discussion of boiler development in general.

As the book is printed in very large type, with broad margins, there is little space to devote to each boiler, and the descriptions are very brief and superficial. We do not see that the book will be of any particular use to an engineer familiar with boiler design and construction; but it may possibly find a useful place on the shelves of public libraries, where there is a constant demand for popular information on technical subjects. Its chief value is as a history, but it is far from complete. The chapter on fire-engine boilers, for example, is practically wholly devoted to types of boilers built in England 30 years and more ago. In the chapter on locomotive boilers we find no mention whatever of the radial-stay type of the Belpaire firebox, or of the Wooten boiler, nor even of the continental design with steam drum in place of steam dome.

The volume closes with a bibliography of books

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relating to steam boilers; but the internal evidence is strong that this was made up from publishers' catalogues, and that the author himself was unfamiliar with many of the books which he included in his list.

Gas Engines.

Reviewed by Storm Bull.*

GASOLINE AND OIL-ENGINES.—Including Producer Gas Plants. By Gardner D. Hiscox, M. E. Including a list of United States Patents issued on the gas-engine industry to the present time. Fifteenth edition, revised and enlarged. New York: The Norman W. Henley Publishing Co. Cloth; 6 × 9¼ ins.; pp. 442; 351 figures in the text. $2.50 net.

Mr. Hiscox's book has already been reviewed twice in the columns of the Engineering News, the first edition on April 22, 1897, and the second on June 2, 1898. The fifteenth edition, now to be reviewed, naturally shows numerous changes, and it is considerably larger than the older editions. But as to the merits of the book the criticisms which were passed upon it in previous reviews still hold good. The theoretical parts are very bad, and although one gross error, noticed in the first review, has now been corrected, yet there are many left. The author has evidently attempted to write a book that could be understood by others than educated engineers, and for this purpose he frequently omits the algebraic formula and instead gives a statement in words, which statement, however, very often is written in such involved English that it is almost impossible to understand it even after a most thorough analysis. On the other hand, he quotes a number of formulae from thermo-dynamics without giving their derivation, but draws his conclusions from them. With these facts in mind it is evident that these theoretical parts can be of very little value to anybody.

With respect to the more practical parts of the book—and these form perhaps three-quarters of it—it is to be stated that they are better than the theoretical parts, but it is very easy to find even here matters to criticise severely. Throughout the book the English is so bad that it is really a wonder that it could pass a printing office with its proofreader. It is probably not an exaggeration to say that the book might have been reduced to three-quarters of its size if the language used had been clear and concise. There are so many repetitions and "big" unnecessary words that the reading of the book for this reason, if for no other, becomes wearisome. To this must be added that the arrangement is abominable. When looking through the book one cannot help getting the impression that the author has written a number of articles on various subjects connected with the gas engines, placed each article on a piece of cardboard, and then has shuffled these articles like an ordinary pack of cards and sent them to the printer in that order. Probably the principal reason for this bad arrangement is the frequent revising of the book; but under such circumstances it is hardly fair to state on the title-page that it is "a new book from cover to cover, entirely reset, revised, and enlarged." As examples of bad arrangement the reviewer will state that in Chapter 19 there is an article on "explosive-engine-testing," another on "back-firing in explosive-motors," and finally the fire underwriters' regulations are given. In Chapter 17 there is first an article on "the measurement of power." This is followed by an article on "the measurement of speed" and by one on "the indicator and its work." The chapter is concluded with two pages treating of the "vibration of buildings and floors by the running of explosive motors."

The one redeeming feature of the book is the large number of illustrations, which in general are very good. They are more numerous and better than in any other American book. In this respect the book is strictly up-to-date, especially as regards American and English practice. This is true both as to details of engines and whole engines. Some very good illustrations of modern producer plants are given.

The popularity of the book, as shown by the large number of editions, is no doubt due to the illustrations, the excellent make-up provided by the publishers, and the low price at which the book is sold.

*Professor of Steam Engineering, University of Wisconsin, Madison, Wis.

PERSONAL HYGIENE

Designed for Undergraduates. By ALFRED A. WOODHULL, A.M., M.D., LL.D. (Princ.), Brigadier General U. S. Army, Retired; Lately Colonel, Medical Department, U. S. Army. 12mo, vii + 220 pages. Cloth, $1.00, net.

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STRUCTURAL ENGINEERING TABLES.—By Edward Godfrey, Structural Engineer for R. W. Hunt & Co. Pittsburg, Pa.: The Author. Flexible leather; 4¼ × 6¾ ins.; pp. 200 + xiv.; illustrated. $2.50, or 5 copies for $10.

Following in the path of the Carnegie "Pocket Companion" and similar handbooks for the structural steel designer, the author of these "Tables" has produced a work that is in many respects distinctly ahead of anything yet published in the English language. He has selected the most necessary elements of the "Pocket Companion," of "Osborn's Tables" and of other similar works, put some of the material into improved form, and added an equal amount of new matter, comprising diagrams, tables and drawings. As a whole, the book represents a very useful collection of structural tables, and a very compact one. But its varied contents are so heterogeneously mixed up, so lacking all orderly arrangement, as to excite one's surprise; this feeling is heightened by the picturesquely diversified typography, which runs into all sizes and styles of type and all manners of tabular arrangement. Fortunately, however, the typography is nowhere unreadable, although both appearance and ease of reference are seriously affected. The drawings with which the book abounds—stress diagrams and the like, as well as drawings of structures and details—deserve much more commendation: they are excellently drawn and, with some exceptions, well reproduced.

To summarize the contents of this handbook would be a lengthy undertaking, and probably a thankless one. Briefly, the book includes tables of commercial steel shapes and their properties, tables of properties of built sections, miscellaneous tables, such as moments of inertia of rectangles and bending capacities of plate girders, tables of trigonometric functions, a novel table of squares of feet, inches and fractions, rivet and bolt tables, and much similar tabular matter; diagrams of ordinary roof trusses, giving stress coefficients for uniform loading; diagrams of hip-and-valley work and portal bracing giving dimensions and stresses (these are interesting because trigonometric functions are avoided in the formulas), and drawings of numerous bridges, roofs, culverts, arches and the like. This list does not give a full idea of the contents, but the matter cited is representative of the whole.

THE MINERAL INDUSTRY DURING 1904.—Founded by the Late Richard P. Rothwell. Prepared by the Editorial Staff of "The Engineering and Mining Journal." The Work of this Volume Has Been More Particularly Under the Supervision of Edward K. Judd. Volume XIII. New York and London: "The Engineering and Mining Journal. Cloth; 6½ × 9½ ins.; pp. 589; illustrated. $5.

MINERAL RESOURCES OF THE UNITED STATES, CALENDAR YEAR 1904.—David T. Day, Chief of Division of Mining and Mineral Resources, U. S. Geological Survey. Washington, D. C.: Pub. Doc. Cloth; 6 × 9¼ ins.; pp. 1,264; two folding plates.

These two well-known statistical publications on the mineral resources and industry of the United States appear nearly simultaneously this year. Previously the publishers of "The Mineral Industry" have been several months ahead of the statisticians of the Geological Survey in giving the year's figures to the public, but this year their work seems to have lagged. To those who have occasion to study statistics of mining and minerals the character and quality of the information given in both volumes is so entirely familiar as to make explanation superfluous. There is nothing in either volume for 1904 to mark its distinction from the volumes of previous years. The important minerals are taken up in alphabetical order, figures of production given, progress of the industry noted and descriptions of the new developments or general advance in technology presented. In some cases the last feature is de-

STEAM-TURBINES

By CARL C. THOMAS, Professor of Marine Engineering, Sibley College, Cornell University. 8vo, xii + 286 pages, 92 figures, 17 plates. Cloth, $3.50.

CONTENTS: Introduction. General Principles Relating to the Action of Steam upon Turbine-buckets. Thermodynamic Principles Involved in the Flow of Steam. Graphical Representation of Work done in Heat Transformations. Calculation of Velocity and Weight of Flow. Velocity as Affected by Frictional Resistances. Experimental Work on Flow of Steam through Orifices, Nozzles, and Turbine-buckets. The Impulse-turbine. The Impulse-and-Reaction Turbine. Types of Turbine, and their Operation. The Marine Steam-turbine. Appendix: Selling Prices of Steam-turbines and Generators, as quoted by various builders in 1905. Notes.

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veloped into a special article by some selected expert. Thus in "The Mineral Industry" there are this year special articles on "Asbestos in Canada," by J. Obalski; "Asphalt in the Indian Territory," by W. R. Crane; "A History of the Barytes Industry," by W. D. Gillman; "Recent Improvements in Lead Smelting," by H. O. Hofman, and "Progress in Gold Milling," by R. H. Richards; besides a number of other articles. In the Geological Survey publication each mineral is, as has long been the practice, reported upon by an expert.

Machine Shop Problems.

MODERN MACHINE SHOP CONSTRUCTION, EQUIPMENT AND MANAGEMENT.—By Oscar E. Perrigo, M. Am. Soc. M. E., Expert in Machine Shop and Factory Organization, Modern Shop Methods, Time and Cost Systems, etc. New York: The Norman W. Henley Publishing Co. Cloth; 7½ x 10½ ins.; pp. 343; 208 figures in the text. $5.

In recent years there has been strenuous activity in certain engineering circles in studying and discussing matters connected with the management of shops, factories and industrial plants, principally machine-building establishments. Such study and discussion is virtually a new industry, which to-day gives employment to not a few "modernizing" or 'industrial betterment" experts. Years earlier progressive shop managers concerned themselves frequently with questions of how to arrange and group their machine tools, how to lay out their new plants or extensions, in order to get maximum output from a shop of given size and to work with best efficiency; that is, at lowest production cost. These questions are nowadays also appropriated by the new class of shop experts. The aggregate might, broadly, be called the study (or science, or art) of manufacturing, although up to the present it has been confined mostly to the machine shop and to the industry of building machines. Machine shop production is to-day almost a differentiated engineering specialty. Mr. O. E. Perrigo attempts in the book under review to give a comprehensive didactic treatment of this subject.

There are two main divisions of this subject which should be kept distinct; they discuss (1) The Plant, or the producing implement, and (2) Operation, or the handling of this implement. They are just as separate and independent as are construction and operation in the case of railways: though inter-related at many points, they are the concern of different classes of men, base on wholly different sets of principles, and have to meet quite different conditions. It is evident in the case of railways that the two divisions should be treated in separate books, rather than in the same covers. We are inclined to think that the same conclusion applies to the subject which Mr. Perrigo undertakes to handle. Certainly, his treatment of the first division, on the shop and its equipment, will not be of much service to either architect or engineer or manufacturing expert, and it is in no sense a comprehensive treatment.

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The author makes three divisions of his subject instead of two, by treating separately of the building in which the shop is housed and the machines and equipment which constitute its working elements. The other main branch, Operation, might also be split into two parts, respectively Shop Operation and Business Management; but the author has little or nothing to say concerning the last-named division.

The author's discussion of his theme is grouped about a specific shop (assumed), whose layout is shown in the first pages. This is a shop of moderate size, for building a general line of machinery of medium weight; it is located on a rectangular plot of ground, which appears to cramp the shop layout. Three-fourths of the book, or more, deals specifically with this shop; already limited to machine shops by its title, the book is thus still further restricted to a specific size and type of shop. As general rules are avoided in treating of shop layout, proportioning of equipment, etc., the book does little more than present a single illustrative case, worked out in detail.

Part I, dealing with the shop buildings, describes typical steel-frame and brick-wall construction, which the author assumes for the shop in question. Chapters describing slow-burning construction and the saw-tooth form of roof exhibit alternative possibilities. Foundations and floors are separately discussed. All these chapters contain many suggestions for proper construction that should be of value to shop stockholders and directors, though they will afford little instruction to the architect or engineer. Fortunately, detailed specifications, or sizes of material, truss members and the like, are not given, so that the use of the book by the layman for designing without the necessary detail knowledge is not to be feared. A succeeding chapter, however, which describes and shows the brick chimney for the plant, does err in this respect, inasmuch as it ends thus:

> The chimney here shown is in every way substantial and reliable, and from the dimensions and proportions given, chimneys of any required capacity, or to suit any condition of surroundings, may be successfully designed and constructed.

This reads like a direct invitation to use the "proportions" of the stack shown for other dimensions or conditions, a dangerous procedure.

Part I. also contains chapters on heating and ventilation, on lighting and on power transmission, of which the last is of little use.

Part II. discusses the equipment of the assumed shop with machines, storage and handling appliances and all other producing devices. It opens with a brief statement, illustrated by plan drawings, of the number and arrangement of the different machines (planers, lathes, millers, grinders, gear-cutters, etc.) in the machine shop proper. No rules or data are given for laying out this equipment, but the specimen shop layout is to be taken on faith by the reader. Then follow seven chapters treating in detail of the equipment of other departments, and of the shop track system and miscellaneous equipment. Their subjects are: Tool Room and Tool Storeroom, Drawing Room, Pattern Shop and Pattern Storage, Foundry, Forge Shop, Shop Transportation Equipment (track system), and the Miscellaneous Equipment. The disposition of space and arrangement of machines and appliances in these departments are here discussed, with immediate reference to the assumed specimen shop. But a more interesting feature is the description and illustration of a large number of special appliances, such as pattern racks, pattern lumber storage and drying racks, case-hardening and annealing furnace for forge shop, pickling vats for foundry, bar-iron racks, shop tracks and cars, blue-print frames, drawing tables and filing cases, and many more of the same class. In this part of the work nearly every shop superintendent and manager may find one or another serviceable hint.

Some general remarks bearing on shop equipment appears also in Part III., especially in a chapter entitled "Efficiency in Manufacturing Operations." In the main, however, this section, entitled "Machine Shop Management," discusses the conduct of the shop departments. Of these the main or machine shop, and the foundry, are most insufficiently handled; a series of blank forms on which shop transactions are ordered or recorded forms the main part of what is given, and these evidently represent only the office or bookkeeping side of shop management, while the problems of the foreman, superintendent or executive are passed over. It is to be remarked that the subjects Methods of Payment for Labor and Improving Labor Efficiency, which have given rise to so much public discussion in recent years, are not touched on. Nor is Cost-keeping discussed or explained; a chapter on "The Problem of Apportioning the Fixed Charges" is only an introduction to such a discussion. Some movements of more or less note receive representation in the closing chapter, which describes very briefly the conduct of a shop mutual aid association, a first-aid equipment, a reading room and a dining room.

In passing opinion on the work, it is necessary to observe the considerable limitation to its apparent scope (as expressed in the title) which is imposed by the author's plan of discussing mainly a single assumed shop, of prescribed character, size and location. By following this plan, the

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author succeeds in presenting many ideas and hints that will be suggestive to those interested in planning or improving a machine shop. The general subject of Machine Shop Operation, or the larger one of Manufacturing Plants, is only grazed by the present book. But the work has much interest as a record, even though far from thorough or comprehensive, of the methods and objects of laying out a machine shop and controlling its operation. For those who are wholly unacquainted with the field of shop production and wish to acquire a general acquaintance in a "popular" way by reading, the book will be specially valuable. The clear and substantial make-up of the work deserves commendation.

Publications Received.

DAS BAUINGENIEURWESEN AUF DER WELTAUSSTELLUNG IN ST. LOUIS IM JAHRE. 1904.—Und die Konstruktion der Grossen Ausstellungsgebäude Daselbst. By E. Probst, Member of the Jury. Reprint from the "Allgemeine Bauzeitung." 1906. Vienna, Austria: The Author. Paper; 11¼ x 17 ins.; pp. 25; 16 plates and 60 text illustrations.

BOARD OF HARBOR AND LAND COMMISSIONERS.—Annual Report for the Year 1905. Boston, Mass.: Pub. Doc. Cloth; 5½ x 9¼ ins.; pp. 96; one folding plate.

BULLETINS, BUREAU OF THE CENSUS.—S. N. D. North, Director. Washington, D. C.: Pub. Doc. Paper; 9 x 11½ ins.
No. 27: Census of Manufactures: 1905. Maryland and District of Columbia. Pp. 33.
No. 28: Census of Manufactures: 1905. Kansas. Pp. 25.

BULLETINS, U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 6 x 9 ins.
No. 272: Taconic Physiography. [Vermont, Massachusetts, New York] By T. Nelson Dale. Pp. 52; 14 plates and three text illustrations.
No. 276: Results of Primary Triangulation and Primary Traverse, Fiscal Year 1904-5. By Samuel S. Gannett. Pp. 263; one folding plate.

COMMERCIAL RELATIONS OF THE UNITED STATES WITH FOREIGN COUNTRIES DURING THE YEAR 1904.—Washington, D. C.: Pub. Doc. Cloth; 5⅝ x 9¼ ins.; pp. xivi. + 858.

A COURSE IN PRACTICIAL MATHEMATICS.—By F. M. Saxelby, M. Sc., B. A., Head of the Mathematical Department, Municipal Technical Institute, Belfast. London, New York and Bombay: Longmans, Green & Co. Cloth; 5½ x 8¼ ins.; pp. 438; 200 figures in the text. $2.25, net.

DAS EISENBAHN UND VERKEHRSWESEN AUF DER WELTAUSSTELLUNG IN ST. LOUIS, 1904.—By Prof. M. Buhle and W. Pfitzner. Reprint from "Dingler's Polytechnisches Journal," with an Appendix on Automobile Exhibits at the World's Exposition at St. Louis, by W. Pfitzner. Berlin: Richard Dietze. Paper; 8¾ x 12¼ ins.; pp. 72 + 16; 244 illustrations in the text. 3 marks; American price, $1.20.

ELECTRIC WIRING, DIAGRAMS AND SWITCHBOARDS.—By Newton Harrison, E. E., Instructor of Electrical Engineering in the Newark Technical School. New York: The Norman W. Henley Publishing Co. Cloth; 5 x 7¼ ins.; pp. 272; 105 figures in the text. $1.50.

ELEMENTARY ELECTRICAL CALCULATIONS. — A Book Suitable for the Use of First and Second Year Students of Electrical Engineering. By W. H. N. James, A. I. E. E., Lecturer and Demonstrator in the Electrical Engineering Department of the Municipal School of Technology, Manchester, and D. L. Sands, Demonstrator and Assistant Lecturer in the Electrical Engineering Department of the Municipal School of Technology, Manchester. London, New York and Bombay: Longmans, Green & Co. Cloth; 5 x 7½ ins.; pp. 216; 52 figures in the text. $1.25.

ELEMENTARY PRACTICAL METALLURGY.—Iron and Steel. By Percy Longmuir, Carnegie Research Scholar and Medallist, Iron and Steel Institute. London, New York and Bombay: Longmans, Green & Co. Cloth; 5 x 7½ ins.; pp. 269; 64 figures, partly in the text. 5s., net; American price, $1.60, net.

THE FIRST COUNTY PARK SYSTEM.—A Complete History of the Inception and Development of the Essex County Parks of New Jersey. By Frederick W. Kelsey, Vice-President of the Original Commission. New York: J. S. Ogilvie Publishing Co. Cloth; 5 x 8 ins.; pp. 300; illustrated. $1.25.

GAS AS A SOURCE OF POWER.—Four papers reprinted from the Journal of the Society of Chemical Industry: I. Generation of Producer, Mond and Blast Furnace Gases, by Willard L. Case; II. Utilization of Gas from Suction Producers, by Oskar Nagel; III. Coke Oven Gas, by C. G. Atwater; IV. The Mond Producer, by J. D. Pennock. New York: H. Schweitzer, 40 Stone St., Secretary New York Section. Paper; 7¼ x 10¾ ins.; pp. 15; several illustrations and tables in the text.

GUATEMALA.—The Country of the Future. A Monograph. By Charles M. Pepper (Senor Don Jorge Munoz, Envoy Extraordinary and Minister Plenipotentiary, Highlands, Washington, D. C.). Paper; 6 x 9 ins.; pp. 80; illustrated.

AN INTRODUCTION TO THE INFINITESIMAL CALCULUS.—Notes for the Use of Science and Engineering Students. By H. S. Carslaw, D. Sc., F. R. S. E., Professor of Mathematics in the University of Sydney. London, New York and Bombay: Longmans, Green & Co. Cloth; 5½ x 8¼ ins.; pp. 103; 20 figures in the text. $1.60, net.

KRANE (Construction and Equipment of Cranes).—Ein Handbuch für Bureau, Betrieb und Studium. By Anton Böttcher. With the collaboration of G. Frasch. Munich and Berlin, Germany: R. Oldenbourg. Cloth; 6½ x 9½ ins.; pp. 500; 492 figures in the text, and 41 tables; 48 plates bound separately. 25 marks; American price, $10.

THE LAST SPIKE.—And Other Railroad Stories. By Cy. Warman. New York: Charles Scribner's Sons. Cloth; 4¾ x 7 ins.; pp. 288. $1.25.

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LOCOMOTIVE TESTS AND EXHIBITS.—The Pennsylvania Railroad System at the Louisiana Purchase Exposition, St. Louis, Mo., 1904. Philadelphia, Pa.: The Pennsylvania R. R. Co. Half leather; 6 × 9¼ ins.; pp. 734; 845 figures, partly in the text.

MECHANICS FOR ENGINEERS.—A Text-Book of Intermediate Standard. By Arthur Morley, M. Sc., University Scholar (Vict.), Senior Lecturer in Engineering in University College, Nottingham. London, New York and Bombay: Longmans, Green & Co. Cloth; 5 × 7½ ins.; pp. 282; 199 figures in the text. 4s.; American price, $1.20, net.

NEW YORK STATE DEPARTMENT OF LABOR.—Fourth Annual Report, for the Twelve Months Ended Sept. 30, 1904 (John McMackin, Commissioner). Albany, N. Y.: Pub. Doc. Cloth; 5⅞ × 9¼ ins.. Part I. Fourth Annual Report of the Commissioner of Labor. Pp. 287. Part II. Eighteenth Annual Report of the Board of Mediation and Arbitration. Pp. 205. Part III. Nineteenth Annual Report on Factory Inspection. Pp. 295. Part IV. (Bound separately) Twenty-second Annual Report of the Bureau of Labor Statistics. Pp. lix. + 864.

THE PREVENTION OF SENILITY AND A SANITARY OUTLOOK.—By Sir James Crichton-Browne, M. D., LL. D., F. R. S., Lord Chancellor's Visitor in Lunacy. London: Macmillan & Co., Ltd. New York: The Macmillan Co. Cloth; 4¾ × 7½ ins.; pp. 141. 75 cts.

PROFESSIONAL PAPERS, U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 9 × 11½ ins.

No. 43: The Copper Deposits of the Clifton-Morenci District, Arizona. By Waldemar Lindgren. Pp. 375; 25 plates (one in pocket) and 19 text illustrations.

RAILROAD COMMISSION OF THE STATE OF TEXAS.—Annual Report for the Year 1905. Austin, Tex.: Pub. Doc. Paper; 6 × 9¼ ins.; pp. 545; numerous folding and other tables.

THE SANITARY VALUE OF A WATER ANALYSIS.—By Leonard P. Kinnicutt. (Reprinted from Science, N. S., Vol. XXIII., No. 576, Pages 56-66, Jan. 12, 1906.) Paper; 6¼ × 9¾ ins.; pp. 22.

DIE SCHIFFSSCHRAUBE.—By Albert Achenbach, Principal of the Royal Naval Academy at Kiel. Part I. Its Development and Graphical Representation. Kiel, Germany: Robert Cordes. Cloth; 6½ × 9½ ins.; pp. 84; 25 plates and two folding tables. 10 marks; American price, $4.

STANDARD REDUCTION FACTORS FOR GASES.—A Number of Tables Necessary for the Reduction of the Volume of Any Gas at Any Temperature, Pressure, and Degree of Saturation to Its Equivalent Volume Under Standard Conditions, Together with a Table for the Numerical Solution of Certain Exponential Equations. By Helon Brooks MacFarland, B. S., M. M. E., Associate Professor of Applied Mechanics, Department of Mechanical Engineering, Armour Institute of Technology, Chicago, Ill. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5⅜ × 9¼ ins.; pp. 54. $1.50.

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ROBERT W. LESLEY,
in "Cement Age," January, 1906.

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Literary Magazines.

The recent rapid commercial development of the South is a theme to which large space is devoted in the February "Review of Reviews." Mr. R. W. Wooley opens a paper on the "Development of Our Gulf Ports" with the statement that New Orleans now ranks second only to New York among America's export ports, while Galveston is third. Gulfport, Miss., leads all domestic ports in its shipments of lumber, Pensacola in sawed timber and Mobile in cross-ties. No longer ago than 1900, when Galveston was all but wiped out by a flood, it ranked eighth among exporting ports. Gulfport was founded only seven years ago. These figures are truly marvelous. In the same magazine is an article describing the Galveston sea-wall and the work of filling in which is now in progress. The sea-wall is 3¼ miles long, 16 ft. high, with a base of 16 ft. and a 5-ft. top. It consumed over 13,000 carloads of material and cost $1,200,000. In the work of grade raising behind the wall nearly 12,000,000 cu. yds. of sand is being placed, at a cost of 18½ cts. per cu. yd. The contract time for completing this work is Jan. 1, 1907.

In the "Atlantic" we find an interesting summary of the developments of the year 1905 in Mexico, which will interest the many American engineers having interest there. A comment of a similar sort may be made with reference to a "Scribner" article, entitled "The New China," by Thomas F. Millard. We may note here merely that this writer declares Japanese influence and money to be mainly responsible for the Chinese boycott of American goods. It is undoubtedly a shrewd business move for Japanese exporters.

Recent progress in photography is summarized in a paper in this month's "World's Work," and a topographical map is shown of a mountainous tract in British Columbia which has been plotted from photographic surveying. In the same magazine there is an interesting account of how Kansas City's park system was created. It is worth noting that among those who were first in starting the public agitation that led to its establishment was the late Robert Gillham, M. Am. Soc. C. E., and "a beautiful roadway now building to connect with Swope Parkway bears the name 'Robert Gillham Road,' in memory of a young engineer who did much for his city."

In the February "Century" Hon. Charles A. Prouty, of the Interstate Commerce Commission, has an admirable paper on Government rate control. If any of our readers have formed their ideas and opinions on the subject of railway rate regulation from the current newspaper comments which have been very largely shaped by the arguments spread abroad by the railway advocates, we commend to them Mr. Prouty's forceful and interesting article.

Pattern Making.

Reviewed by Wm. W. Bird.*

PRACTICAL PATTERN-MAKING.—By F. W. Barrows. New York: The Norman W. Henley Publishing Co. Cloth; 5 × 7½ ins.; pp. 326; 141 figures in the text. $2.

Wherever the author has confined himself strictly to his subject he has made this book interesting and instructive. His great fault is the persistent quoting of the first person in his so-called statements of facts, many of which are matters of personal opinion. He deals with the general subjects pertaining to the trade, and all are well treated and suggestive.

The chapter on mathematics is rather out of place; the space could be better taken up with recent developments in machine molding as related to pattern-making, a subject on which he has little to say.

The chapter on costs is disappointing and incomplete; the hints on how to keep the cost, however, are very good.

On the whole, the book is a valuable one, and anyone interested in this subject cannot fail to be benefited by reading Practical Pattern Making.

*Professor of Mechanical Engineering and Director of the Washburn Shops, Worcester Polytechnic Institute, ...

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THE ARCHITECTS' DIRECTORY AND SPECIFICATION INDEX.—For 1905-1906. Published Annually. Seventh Edition. New York: William T. Comstock. Cloth; 7 × 10 ins.; pp. 176. $2 net.

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